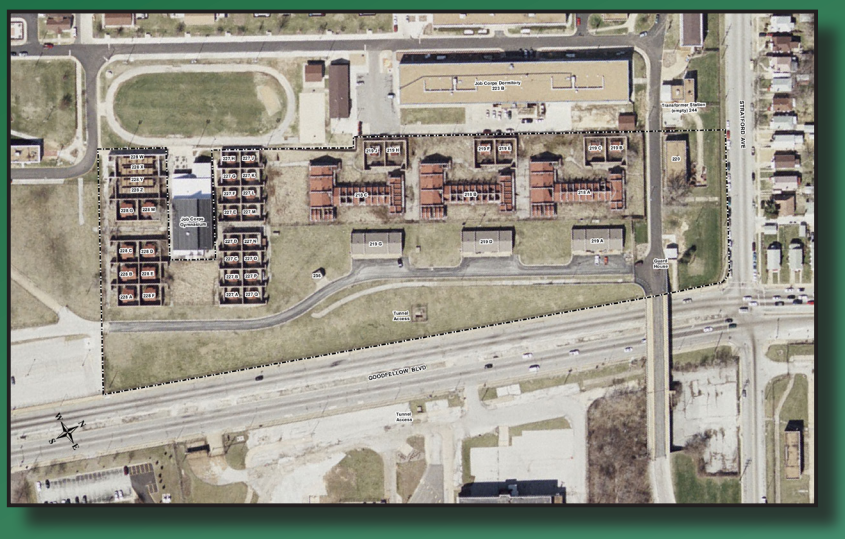
Final Uniform Federal Policy–Quality Assurance Project Plan

RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant Former Hanley Area

St. Louis, Missouri



Prepared for:

US Army Corps of Engineers
Kansas City District

88th Regional Support Command

US Army Environmental Command

Prepared by: CH2MHILL®

December 2013

40470213

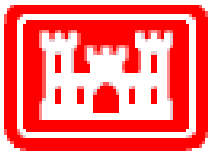
Final Uniform Federal Policy-
Quality Assurance Project Plan

RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

Contract No. W912DQ-11-D-3005 Task Order 0009

Prepared for



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December 2013

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STATEMENT OF TECHNICAL REVIEW

Remedial Investigation/Feasibility Study Activities for Operable Unit 2 (Vapor Intrusion Pathway) at the St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Draft Final Uniform Federal Policy-Quality Assurance Project Plan

The CH2M HILL team has completed the technical review of the submittal of the Final Uniform Federal Policy-Quality Assurance Project Plan. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, using justified and valid assumptions, was verified, including review of assumptions; methods, procedures, and material used in analyses; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with the law and existing U.S. Army Corps of Engineers policy.

Technical Reviewer	Signature	Date of Review
Susanne Borchert	S. Borchert	07/22/2013
Loren Lund	Loren Lund	07/22/2013

Quality Control System Manager or Project Manager		Independent Technical Review Leader
Chris English		Susanne Borchert
Signature	Date	Signature
Christopher E. English	07/22/2013	S. Borchert

Executive Summary

This Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) presents the data quality objectives (DQOs), analytical program, and methodology for remedial investigation (RI) activities for Operable Unit (OU) 2—Vapor Intrusion (VI) Pathway at the St. Louis Ordnance Plant, former Hanley Area, in St. Louis, Missouri. This UFP-QAPP includes a project-specific field sampling plan (FSP; Appendix C) and a site safety and health plan (Appendix D). The UFP-QAPP was prepared under Contract No. W912DQ-11-D-3005, Task Order 0009, between the U.S. Army Corps of Engineers (USACE)–Kansas City District and CH2M HILL.

Response actions at the former Hanley Area are divided into two OUs:

- OU-1: Actions Addressing Contaminated Soil, Powder Well Sediment, and Groundwater Concerns
- OU-2: VI Pathway

OU-1 response actions were presented in a decision document (CH2M HILL 2011a) and performed in 2012 (CH2M HILL 2012a). The Army is currently performing long-term management (LTM) activities under OU-1. OU-2 RI activities are the subject of this UFP-QAPP.

Project Background

The St. Louis Ordnance Plant operated from 1941 to 1945 as a small arms manufacturing facility. The plant was divided into two areas designated No.1 (east of Goodfellow Boulevard) and No. 2 (west of Goodfellow Boulevard). The former Hanley Area consists of 14.68 acres at the northeastern end of Plant Area No. 2 at the intersection of Stratford Avenue and Goodfellow Boulevard. The former Hanley Area takes its name from Hanley Industries, Inc., which leased the 14.68 acres in 1959 and conducted operations there through 1979. Hanley used the site for research, development, manufacture, and testing of various explosives.

The former Hanley Area is bordered by the Job Corps Training Center on the west and residential areas to the north, west, and southwest. The area to the east, across Goodfellow Boulevard from the site, is now owned by the General Services Administration.

Ammunition and explosives manufacturing operations at the former Hanley Area resulted in soil and sediment contamination onsite and groundwater contamination onsite and offsite. Between 1979 and 2007, various environmental investigations were performed at the former Hanley Area to assess the nature and extent of contamination. In 2008, the Army conducted an RI to fill data gaps from the previous investigations. The RI objectives were to delineate the nature and extent of contamination and to characterize the risk, if any, posed to human health and the environment at the site. Results from the 2008 RI and previous investigations were presented and discussed in the RI report (CH2M HILL 2009).

To address unacceptable human health risks identified in the RI report, the Army performed a remedial action for OU-1 in 2012. The OU-1 remedial action addressed contamination in surface soil, powder well sediment, and groundwater. During the OU-1 remedial action, several VI investigations were performed at various residences north of Stratford Avenue resulting in no conclusive link between former Hanley Area groundwater contaminants and indoor vapors. However, because offsite groundwater contamination remains, and the potential for contaminant migration into offsite residences and non-residential buildings exists, additional VI pathway investigations will be required. The VI pathway is the focus of OU-2 and the subject of this UFP-QAPP.

Project Objectives and Approach

The primary objective for OU-2 is to evaluate the VI pathway and implement appropriate remedial actions, if necessary, to protect human health and the environment. The project stakeholders held an OU-2 strategy meeting in Kansas City to develop RI- and feasibility study (FS)-specific objectives and discuss the technical approach for the RI/FS. Attendees at the meeting represented USACE, U.S. Army Environmental Command (USAEC), 88th Regional Support Command (RSC), CH2M HILL, Missouri Department of Natural Resources

(MDNR), Missouri Department of Health and Senior Services (MDHSS), and U.S. Environmental Protection Agency (USEPA) Region 7. The stakeholders discussed the following RI/FS objectives:

- Determine whether VI of site-related volatile organic compounds (VOCs) is occurring and is significant at offsite residences.
- Determine whether VI of site-related VOCs could potentially occur to a significant extent in the future at offsite residences.
- Maintain proactive communication and responsiveness to the public throughout the OU-2 RI/FS.
- Obtain sufficient RI data to develop remedial alternatives during the FS (if needed).
- Develop a decision matrix that includes short-term and long-term response actions.

To achieve the objectives, the RI will assess the VI pathway at select offsite residences north of the former Hanley Area. In addition, the RI will assess potential VI impacts in the main onsite tunnel system and, if accessible, a small utility tunnel that is suspected to connect former Building 220 with a nearby Job Corps building (described as “Transformer Station” in Figure 2), as well as potential VI impacts associated with Plume C, an onsite groundwater plume consisting primarily of carbon tetrachloride (CT), near the Job Corps training facility located west of the former Hanley Area. Work in the areas (residences north of the former Hanley Area, near Plume C, and in the tunnel system) will be performed in a phased approach; the stakeholders will use the results from the initial phase to determine the scope of additional work, if necessary, during subsequent phases of investigation.

The proposed subslab soil gas, indoor and outdoor air, tunnel air sampling, and groundwater sampling will be conducted in accordance with this UFP-QAPP, the FSP (Appendix C), and the site safety and health plan (Appendix D).

Contents

Appendixes

Figures

Tables

Abbreviations and Acronyms

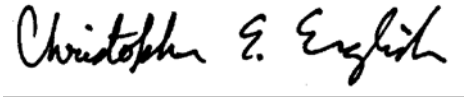
A2LA	American Association of Laboratory Accreditation
ADR	automatic data review
amsl	above mean sea level
ASTM	ASTM International
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
COPC	chemical of potential concern
CT	carbon tetrachloride
DCA	dichloroethane
DCE	dichloroethene
DL	detection limit
DoD	Department of Defense
DQO	data quality objective
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ELCR	excess lifetime cancer risk
FD	field duplicate
FS	feasibility study
FSP	field sampling plan
GC/MS	gas chromatography/mass spectrometry
GPS	global positioning system
HAZWOPER	hazardous waste operations and emergency response
HHRA	human health risk assessment
HQ	hazard quotient
ICAL	initial calibration
IDW	investigation-derived waste
L	liter
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
LSOP	laboratory standard operating procedure
LTM	long-term management
LUC	land use control
LUCIP	LUC Implementation Plan
MDHSS	Missouri Department of Health and Senior Services
MDNR	Missouri Department of Natural Resources
MPC	measurement performance criteria
MS	matrix spike

MSD	matrix spike duplicate
MSSL	medium-specific screening level
µg/m^3	microgram per cubic meter
µg/L	micrograms per liter
NA	not applicable
NIST	National Institute Standards and Technology
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PCE	tetrachloroethene
PDF	portable document format
PM	project manager
PP	private property
PQO	project quality objective
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QSM	Quality Systems Manual
%R	percent recovery
RAGS	Risk Assessment Guidance for Superfund
RAL	Removal Action Level
RF	response factor
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RL	reporting limit
ROE	right of entry
RPD	relative percent difference
RRC	Regional Readiness Command
RSC	Regional Support Command
RSD	relative standard deviation
RT	retention time
RRT	relative retention time
RSL	Regional Screening Level
SEDD	Stage 2A electronic data deliverable
SIM	selective ion mode
SLAAP	St. Louis Army Ammunition Plant
SOP	standard operating procedure
TBD	to be determined
TCA	trichloroethane
TCE	trichloroethene

TeCA	tetrachloroethane
UCL	upper confidence limit
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
USACE	U.S. Army Corps of Engineers
USAEC	U.S. Army Environmental Command
USEPA	U.S. Environmental Protection Agency
VI	vapor intrusion
VISL	vapor intrusion screening levels
VOA	volatile organic analysis
VOC	volatile organic compound

Worksheet #1 and #2—Title and Approval Page

Project Name and Site Location:	Operable Unit (OU) 2, St. Louis Ordnance Plant, former Hanley Area St. Louis, Missouri
Contract Number:	W912-DQ-11-D-3005, Task Order 0009
Document Title:	*Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP)* *RI/FS Activities for Operable Unit 2 Vapor Intrusion Pathway at the St. Louis Ordnance Plant, former Hanley Area*
Lead Organization:	U.S. Army Corps of Engineers (USACE), Kansas City District 601 East 12th Street/CENWK-PM-ES Kansas City, MO 64106 E-mail: josephine.m.newton-lund@usace.army.mil
Lead Regulatory Organization:	Missouri Department of Natural Resources (MDNR), Federal Facilities Section Hazardous Waste Program 1730 East Elm Street Jefferson City, MO 65101 E-mail: jim.harris@dnr.mo.gov
Contractor's Contact Information:	CH2M HILL 1034 South Brentwood Boulevard, Suite 2300 St. Louis, MO 63117 E-mail: chris.english@ch2m.com
Identify Regulatory Program:	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
List organizational partners (stakeholders) and connection with lead organization:	U.S. Army Environmental Command (USAEC) USACE, Kansas City District, Lead Agency 88th Regional Support Command (RSC) MDNR, Federal Facilities Section, Hazardous Waste Program, Lead Regulatory Agency U.S. Environmental Protection Agency (USEPA), Region 7, Regulatory Support
List dates and titles of work plan documents written for previous site work, if applicable:	Final Work Plan, Vapor Intrusion Assessment, St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri. March 2008. Work Planning Documents, Remedial Investigation, St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri. May 2008. Technical Memorandum, Vapor Intrusion Assessment Work Plan Addendum, Former Hanley Area, St. Louis Ordnance Plant, St. Louis, Missouri. May 20, 2011. Technical Memorandum, Vapor Intrusion Assessment Work Plan Addendum, Revision 1, Former Hanley Area, St. Louis Ordnance Plant, St. Louis, Missouri. December 8, 2011.
Preparation Date:	February 1, 2013



2/1/13

Chris English, CH2M HILL
CH2M HILL's Project Manager (PM)

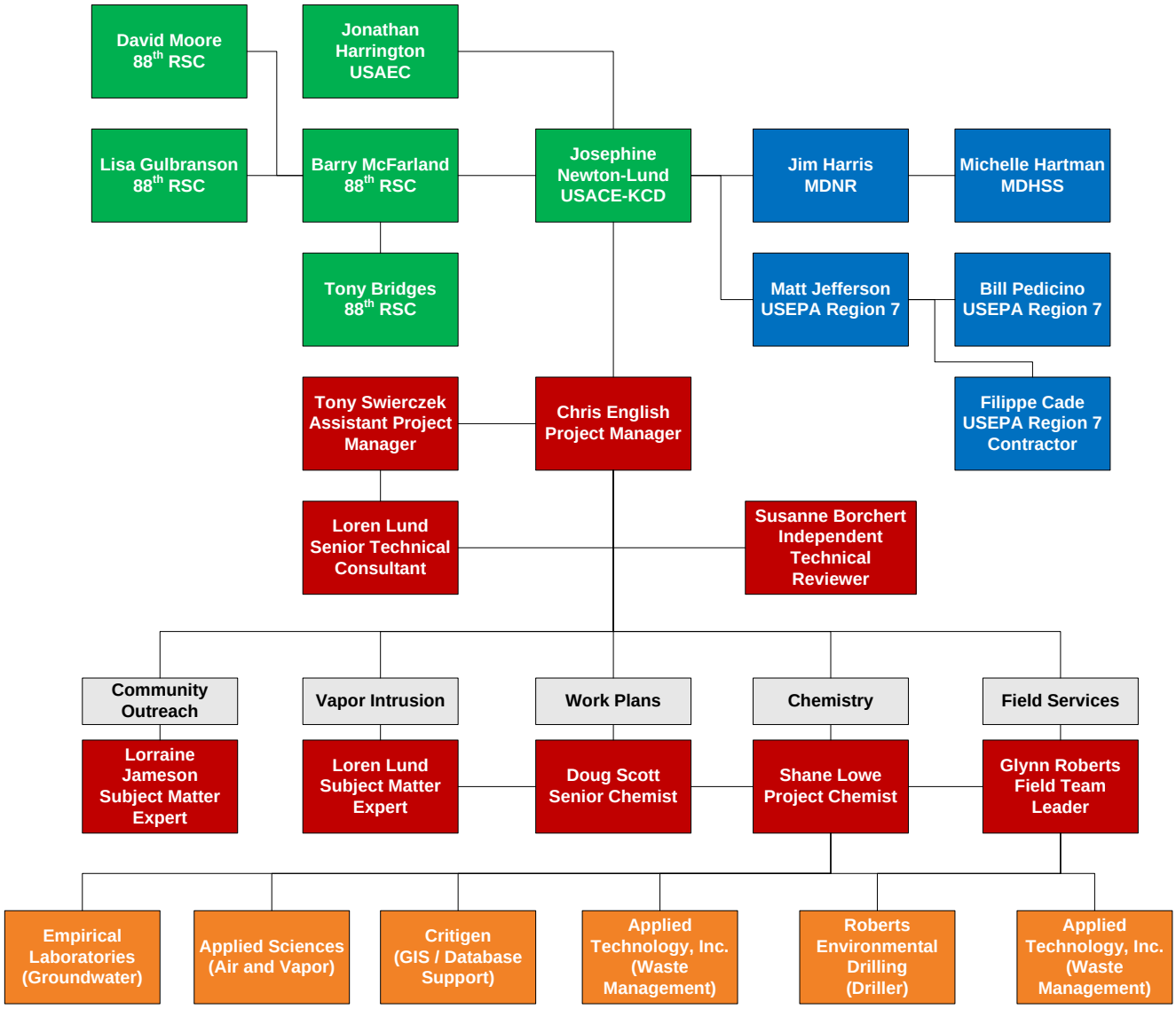
Date

2/1/13

Josephine Newton-Lund, U.S. Army Corps of Engineers
Technical PM

Date

Worksheet #3 and #5—Project Organization and QAPP Distribution



LEGEND:

- Army Stakeholders
- Regulatory Stakeholders
- CH2M HILL Team Members
- CH2M HILL Subcontractors

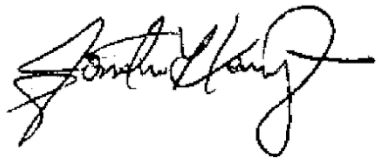
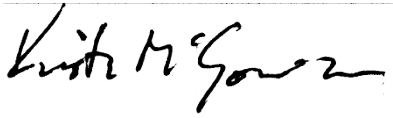
Quality Assurance Project Plan (QAPP) Distribution

Document Title: Uniform Federal Policy-Quality Assurance Project Plan
RI/FS Activities for Operable Unit 2 Vapor Intrusion Pathway at the St. Louis Ordnance Plant, Former Hanley Area
Contract No. W912DQ-11-D-3005 Delivery Order No. 0009

Recipient	Organization	Electronic copies	Hard Copies
Jonathan Harrington	USAEC	x	x
Josephine Newton-Lund	USACE, Kansas City District	x	x
Lisa Gulbranson	88th RSC	x	
Dave Moore	88th RSC	x	
Barry McFarland	88th RSC	x	x
Tony Bridges	88th RSC		x
Jim Harris	MDNR	x	x
Michelle Hartman	Missouri Department of Health and Senior Services (MDHSS)	x	x
Matt Jefferson	USEPA, Region 7	x	x
Bill Pedicino	USEPA, Region 7	x	x
Filippe Cade	Professional Environmental Engineers	x	
Chris English	CH2M HILL, Inc.	x	x
Administrative Record	Julia Davis Branch Library		x

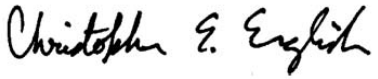
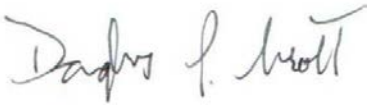
Worksheet #4, #7, and #8—Personnel Qualifications and Signoff Sheet

Organization: Army

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature*/Date
Jonathan Harrington	USAEC/Project Manager (PM)	B.G.S., 20 years of experience	Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-hour Training; 8-Hour Refresher; NIOSH 582 Equivalency Course; MDNR-Certified Asbestos Air Sampling Professional; USEPA/U.S. Department of Housing and Urban Development-Accredited Lead-Based Paint Inspector/Risk Assessor Refresher Training; USEPA/AHERA-Accredited Asbestos Inspector/Management Planner/Project Designer/Contractor Supervisor Refresher Training	
Josephine Newton-Lund	USACE/PM	B.A., 28 years of experience	Project Management Professional; HAZWOPER 40-hour Training; 8-Hour Refresher; Cardiopulmonary Resuscitation and First-Aid	
Dr. Krista McGowan	USACE/chemist	Ph.D., 23 years of experience	HAZWOPER 40-hour Training; 8-hour refresher; tri-service environmental risk assessment working group meeting (VI)	
Dave Moore	88th RSC Directorate Public Works, Chief Environmental Division	B.A., 13 years of experience	Specialized in Supervisory/Project Management Professional; Directorate Public Works Management Orientation; International Organization for Standardization (EMS) Lead Auditor Course; Risk Management Program USEPA Region 5; Resource Conservation and Recovery Act Hazardous Waste; U.S. Department of Transportation Hazardous Waste; Environmental Compliance Assessment Training; Hazardous Materials/Waste Generator Training; P2 Assessment Training; Hazardous Materials Handler Training; Hazardous Waste Management Training	
Barry McFarland	88th RSC			MCFARLAND.BARRY.LEWIS.1264368223 Digitally signed by MCFARLAND.BARRY.LEWIS.1264368223 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=CONTRACTOR, cn=MCFARLAND.BARRY.LEWIS.1264368223 Date: 2013.02.06 09:20:02 -06'00'

*Signatures indicate personnel have read and agree to implement this UFP-QAPP as written.

Organization: CH2M HILL

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature*
Chris English	PM/quality control (QC) officer	M.S., 16 years of experience	Licensed professional engineer, Missouri; HAZWOPER 40-hour training; 8-hour refresher; USACE construction quality management certification	
Anthony Swierczek	Assistant PM/QC systems manager	B.S., 10 years of experience	HAZWOPER 40-hour Training; 8-Hour Refresher; USACE Construction Quality Management Certification; Cardiopulmonary Resuscitation and First Aid; 10-hour Occupational Safety and Health Administration (OSHA) Construction Safety Training	
Doug Scott	Senior chemist	A.S., 27 years of experience	No specialized training	
Loren Lund	Toxicologist and CH2M HILL vapor intrusion (VI) and human health risk assessment (HHRA) practice leader	Ph.D., 24 years of experience	VI assessment/mitigation; HHRA; cardiopulmonary resuscitation and first aid	
Glynn Roberts	Field team leader	B.S., 10 years of experience	HAZWOPER 40-hour training; 8-hour refresher; 10-hour OSHA Construction Safety Training; USACE Construction Quality Management Certification; cardiopulmonary resuscitation and first aid/AED	
Mark Orman	Health and safety manager	B.S., 20 years of experience	Certified safety professional; certified hazardous materials manager	

*Signatures indicate personnel have read and agree to implement this UFP-QAPP as written.

Worksheet #6—Communication Pathways

Communication Drivers	Organization	Name	Contact Information	Procedure (Timing, Pathways, etc.)
Communication with USACE (lead agency)	USACE PM	Josephine Newton-Lund	(816) 389-3912	Primary point of contact for USACE; can delegate communication to other internal or external points of contact; receives direction from USAEC; provides direction to CH2M HILL.
Communication with MDNR	MDNR PM	Jim Harris	(573) 522-1892	Primary point of contact for MDNR; can delegate communication to other internal or external points of contact; provides technical input and recommendations to USACE PM.
Communication with CH2M HILL	CH2M HILL PM	Chris English	(314) 335-3012	Primary point of contact for CH2M HILL; can delegate communication to other internal or external points of contact; provides technical input and recommendations to USACE PM. Receives direction from USACE.
Secondary point of contact for CH2M HILL	CH2M HILL assistant PM	Anthony Swierczek	(314) 335-3043	Receives direction from CH2M HILL PM; provides input to CH2M HILL's PM and project team.
Primary point of contact for QC issues	QC systems manager	Anthony Swierczek	(314) 335-3043	The QC systems manager will communicate directly with the PM. The QC systems manager's duties and responsibilities include the following: • Supervising all QC aspects of the project to ensure compliance with contract plans and specifications • Managing the QC program • Approving all submittals and supervising all QC procedures
Progress of field program	CH2M HILL field team leader/QC officer	Glynn Roberts	(314) 335-3038	Conveys progress of field activities, including deviations from the QAPP; communication with CH2M HILL PM and project chemist, and others as directed by them; directs CH2M HILL field support staff; provides daily safety briefings and directs onsite safety activities; communicates with local officials and property owners.
Data tracking from collection through analysis and upload to database	Critigen data manager	Dan Moore	(314) 335-3029	Project chemist/data validator will work in conjunction with the data manager to track data from sample collection through upload to the database. Also responsible to verify that input/outputs from the database are reviewed for completeness and accuracy.
Field and analytical corrective actions; release of analytical data	CH2M HILL project chemist	Doug Scott	(970) 731-0636	Verifies that the QAPP requirements are met by the laboratory and field staff. Also, provides direction regarding requirements for corrective actions for field and analytical issues; evaluates and releases validated analytical results to the CH2M HILL PM.

Communication Drivers	Organization	Name	Contact Information	Procedure (Timing, Pathways, etc.)
Health and safety issues	CH2M HILL health and safety manager	Mark Orman	(414) 847-0597	Supports the CH2M HILL project team by developing site safety and health requirements; approves activity hazard analyses; conducts field audit(s).
Primary point of contact for Empirical Laboratories	Empirical Laboratories PM	Sonya Gordo	(877) 345-1113	Primary point of contact for Empirical Laboratories. Receives direction from CH2M HILL. Responsible for ensuring the QAPP requirements are met by the laboratory.
Primary point of contact for Applied Sciences Laboratory	Applied Sciences Laboratory PM	Ben Thompson	(541) 768-3132	Primary point of contact for Applied Sciences Laboratory receives direction from CH2M HILL. Responsible for ensuring the QAPP requirements are met by the laboratory.

Worksheet #9—Project Scoping Session Participants Sheet

Operable Unit 2—Vapor Intrusion Strategy Meeting

A meeting was held on September 19, 2012, at the USACE–Kansas City District office, to discuss the VI pathway strategy for OU-2 at the St. Louis Ordnance Plant, former Hanley Area. The following is the agenda presented during the meeting:

- Introduction and Background
- Roles and Responsibilities
- Current Status of OU-2 Activities
- OU-2 Proposed Approach
- OU-2 remedial investigation (RI)/feasibility study (FS) Schedule for FY13-FY14
- Conclusion/Wrap Up

The attendee list, meeting minutes, figure, and slide presentation are provided in Appendix A. Stakeholder endorsement of the RI approach was achieved during the OU-2 strategy meeting, and the key decisions are summarized in the following paragraphs.

A phased approach, or "follow-the-evidence-approach," will be performed during the OU-2 RI. The first phase of the RI will begin by assessing shallow groundwater conditions (that is, groundwater at its first occurrence) near residences located immediately downgradient of the former Hanley Area. Volatile organic compound (VOC) concentrations in groundwater will be compared against conservative risk-based VI screening levels (VISLs). Based on results of the groundwater investigation, a VI assessment at the nearby residences located within 100 feet of groundwater VOC concentrations above VISLs may be conducted.

Colocated shallow and deep overburden monitoring well pairs will be installed along Stratford Avenue to refine the understanding of VOC contamination and groundwater flow direction and gradient north and northwest of the former Hanley Area. Shallow wells will be installed near MW-107, MW-108, and MW-109 because the wells were installed at the overburden/weathered shale contact and their well screens are fully submerged.

The newly proposed onsite colocated well pair west of MW-118 will assess the potential for VI onto Job Corps property and to confirm the adequacy of the land use control (LUC) boundaries.

At the request of MDNR, a colocated well pair will be installed further west of the originally-proposed colocated well pairs along Stratford Avenue. The Army agreed to install this additional colocated well pair under the condition that the analytical results at this colocated well pair would not necessarily trigger the need for additional monitoring wells or VI assessments; that determination would be based on the results from the colocated pair and others further east (closer to the former Hanley Area).

Concurrent with the groundwater investigation, VI assessments will be conducted at Private Property (PP)-2 through PP-5 and PP-17. The Army has completed at least one VI assessment at PP-1 through PP-3 and PP-17. The Army was unable to conduct a VI assessment at PP-4 because the owner did not respond to the Army's right-of-entry (ROE) requests in 2012. Because of the historical groundwater concentrations at monitoring well MW-109 (trichloroethene [TCE] slightly exceeded the VISL of 1.1 micrograms per liter [µg/L] between April 2007 and December 2011), a VI assessment will be conducted at PP-5 (subject to ROE acceptance), located within 50 feet of MW-109. The VI pathway will be assessed by performing three rounds of VI assessments at PP-2 through PP-5 and PP-17 (subject to ROE acceptance by the property owners).

The screening criteria for groundwater, subslab soil gas, and indoor air were also presented during the strategy meeting. In addition to reviewing other lines of evidence, sample results will be compared against the following screening criteria:

Groundwater—In March 2012, USEPA released a VISL calculator that provides conservative default VISLs. The VISLs (June 2013 update) for groundwater will be used and are based on residential (or commercial/industrial) use, an attenuation factor of 0.001 for groundwater-to-indoor air, an excess lifetime cancer risk (ELCR) of 1×10^{-6}, and/or a noncancer hazard quotient (HQ) of 1.0.

Indoor and Outdoor Air—The target indoor air concentrations provided in the VISL calculator will be used and based on the ELCR and HQ identified above. Tunnel air sample results will also be evaluated using the ELCR and HQ identified above. Outdoor air data will be used for comparison with indoor air concentrations to determine if the measured indoor air concentrations are associated with outdoor air infiltration.

Subslab Soil Gas—The target subslab and exterior soil gas concentrations provided in the VISL calculator will be used and based on the ELCR and HQ identified above. The target subslab soil gas is the target indoor air concentration divided by the USEPA generic attenuation factor for soil gas (default value = 0.1).

The following action items were identified during the meeting:

- The Army will determine whether the upcoming community outreach effort will be a public availability session or an updated fact sheet and letter to the public.
- Josephine Newton-Lund/USACE will contact Rosalind Portis of the Job Corps to request holding a future public availability sessions at the Job Corps facility.
- CH2M HILL will prepare an OU-2 work plan that incorporates the discussions held during the OU-2 strategy meeting.
- Jonathan Harrington/USAEC will discuss the possible investigation of a nearby day care facility with USAEC management. This topic was broached by MDHSS during the meeting.

Day Care Center Investigation Approach

In response to discussions at the September 19, 2012, meeting, the Army developed an investigation approach for the day care center. Representatives from USAEC (Jonathan Harrington), 88th RSC (Barry McFarland), USACE (Josephine Newton-Lund), and CH2M HILL (Chris English, Loren Lund, and Anthony Swierczek) participated in a teleconference on September 26, 2012. The investigation approach was subsequently discussed among technical experts and senior management within USACE and USAEC. All parties endorsed the investigation approach.

To maintain a focused, “follow-the-evidence” approach, the Army will perform an investigation at the day care center under the following conditions:

- The Army will install and sample groundwater monitoring wells along Stratford Avenue as discussed during the September 19, 2012, OU-2 strategy meeting and described above.
- If any site-related VOCs exceed VISLs in the shallowest water-producing well pairs at MW-107, MW-108, or MW-109, an investigation at the day care center will be performed as follows:
  - Install a colocated well pair south of the day care center, along the easement of Henner Avenue.
  - Install a second colocated well pair west of the day care center in the easement of an existing alleyway.
  - Following development, the wells will initially be sampled for only the VOCs that exceeded VISLs in the shallowest water-producing wells in each well pair at MW-107, MW-108, and MW-109 along Stratford Avenue. The approach will help in determining if there is a potential exposure pathway between the former Hanley Area and the day care center, and whether the former Hanley Area,

rather than other properties closer to the day care center that also could be VOC sources, is a likely source of any potential contamination. Due to temporal variability observed with 1,2-dichloroethane (DCA) concentrations in MW-107, the wells should be sampled on at least two occasions separated by a minimum of 3 months between sampling events.

- If the wells do not contain target VOC concentrations above VISLs, the Army will consider abandoning the monitoring wells or allow the regulators to sample the wells during future sampling events. Under this scenario, as there would be no detections from upgradient Army monitoring wells to indicate the former Hanley Area as a source of other VOCs that may be found above VISLs in samples collected by the regulators, the Army will not be responsible for additional investigations into the source of such contamination.
- If the wells do contain target VOC concentrations above VISLs, the Army and project stakeholders will discuss the appropriate next steps in the investigation. Follow-on investigation measures would likely involve concurrent indoor air, outdoor air, and subslab soil gas sampling at the day care center.

If none of the concentrations of site-related VOCs exceed VISLs in the shallowest water-producing well pairs at MW-107, MW-108, or MW-109, or if deep wells contain VOCs above VI screening levels, but the corresponding shallow wells do not, then no investigation will be performed at the day care center. The procedure is appropriate because VOCs are not migrating along the water table downgradient of Stratford Avenue, toward the day care center, and therefore could not contribute to VI at the day care center.

The Army presented the approach above in a technical document titled *Investigation Approach for Day Care Center at 4725 Goodfellow Boulevard, St. Louis, Missouri* (CH2M HILL 2012b). The Army submitted the technical document to MDNR and USEPA for review on October 22, 2012.

Missouri Department of Natural Resources Feedback on Day Care Center Investigation Approach

After reviewing the day care center investigation approach technical paper, MDNR sent a letter to USACE–Kansas City District on November 8, 2012, concurring with the investigation approach and requesting one additional monitoring well in the alley near PP-11. MDNR noted that the well would provide additional information on groundwater flow in the area of concern (Stratford Avenue, Henner Avenue, Irving Avenue, and Goodfellow Boulevard), and analytical results from the well would provide an additional line of evidence regarding whether the former Hanley Area is potentially impacting groundwater near the day care center.

In response to MDNR's request, the Army will install a colocated well pair in the alley near PP-11 under the same conditions as the other two well pairs associated with the day care center investigation. If installed, the colocated well pair near PP-11 will be developed and sampled identically to the other well pairs associated with the day care center investigation.

Interim Vapor Intrusion Mitigation Approach

After reviewing Army responses to MDNR and MDHSS comments on the draft final OU-2 work plan, MDNR sent a letter to USACE–Kansas City District on March 13, 2013. Feedback received from MDNR and MDHSS on the VI assessment approach discussed concerns regarding prompt mitigation at residences where contaminants from the former Hanley Area may be contributing to VOCs in indoor air. As discussed in the June 21, 2013, Army correspondence to MDNR, the Army will be prepared to promptly implement an interim remedy at residences with excessive risk that may be caused by contamination from the former Hanley Area. The decision to implement an interim remedy will be made in accordance with the flow diagram presented as Figure 13 in the OU-2 work plan.

The Army will be prepared to promptly implement an interim remedy in the event that site-related contaminants are resulting in excessive risk. The interim remedy is defined in the following paragraphs.

If the OU-2 decision document recommends no action for that residence (for instance, because subsequent OU-2 investigations indicate that the exceeding concentrations are actually caused by background sources and are not site-related), the Army will notify the resident that the interim remedy will be terminated, but that the selected interim remedy (that is, air purifier unit) can continue to be operated by the resident under the condition that the Army would not be responsible for further maintenance costs (including reimbursement of power costs) associated with the interim remedy.

The decision logic for implementing an interim remedy is based on the following rationale:

1. The Army will consider an interim remedy for contamination that appears to be site-related, based on multiple lines of evidence presented in the OU-2 RI work plan and summarized in the notes of Figure 13. The Army will not be responsible for mitigating indoor air contamination that can be attributed to background sources. However, the Army will promptly share its findings with the resident and note the possible background sources that the resident can then address.
2. In the decision logic, "excessive risk" will correspond to site-related VOC concentrations that exceed risk levels defined by USEPA's Office of Solid Waste and Emergency Response (OSWER) for the development of Removal Action Levels (RALs) (USEPA 2008). Site-related VOC concentrations will be compared against screening levels corresponding to the following target risk levels. Concentrations above the screening levels will indicate excessive risk and the need for interim action:
    a. Carcinogenic effects: a residential individual excess lifetime cancer risk of 1×10^{-4}. A 10^{-4} risk level corresponds to the upper end of USEPA's acceptable risk range of 10^{-6} to 10^{-4} as discussed in the National Oil and Hazardous Substances Pollution Contingency Plan.
    b. Noncarcinogenic effects: an HQ of 3 for residential land use. As noted in the OSWER memorandum, an HQ of 3 represents the upper end of the uncertainty surrounding the reference dose (RfD) and reference concentration (RfC), which are used to assess the potential for a toxic effect. As noted by OWSER (USEPA 2008):

        > *Given the order of magnitude uncertainty surrounding the RfD and RfC, and the fact that RALs are not meant to define protective levels, generic RALs calculated using USEPA's RfDs and RfCs correspond to an HQ of 3. As a science policy choice, OSWER selected an HQ of 3 as the target risk level for the noncancer RALs to distinguish the values from cleanup levels commonly set at an HQ of 1. Calculated RALs are set at a higher risk level because they are not meant as cleanup level; instead, RALs support the need for a removal action.*

3. The Army will consider provisional short-term action levels for TCE in determining whether to implement an interim action. These action levels are based on the potential occurrence of developmental health effects (fetal cardiac malformations) related to exposures to pregnant women during the first trimester of pregnancy. Guidance for how the short-term limits should be used in VI assessments and subsequent remedial/mitigation responses is extremely limited, making it difficult for stakeholders to determine how much confidence to place in these provisional short-term action levels. The Army will discuss indoor air TCE concentrations with MDNR to determine an appropriate next step if indoor air concentrations of TCE exceed one or more of the provisional short-term action levels for TCE that are used by USEPA to make risk management decisions.

If site-related VOCs indicate excessive risk or if site-related concentrations exceed provisional short-term action levels for TCE (as agreed upon by the Army and MDNR), the Army may immediately (within 1 week) collect another round of indoor air samples on a rapid-turnaround basis (5 business days) or perform an indoor HAPSITE survey to confirm the findings. Alternatively, the Army may forego the confirmation sampling or HAPSITE survey and implement the interim action.

Worksheet #10—Conceptual Site Model

Site Location and Description

Former Hanley Area

The former Hanley Area is located in the Mark Twain/1-70 Industrial neighborhood. The Mark Twain/I-70 Industrial neighborhood is bounded by I-70 to the north, Natural Bridge Avenue to the south, North Kingshighway Boulevard to the east, and Philbrook Avenue to the west. The former Hanley Area (Army Reserve Facility ID MO030, 6400 Stratford Avenue) consists of 14.68 acres on the western boundary of the city limits of St. Louis, 0.25 mile south of the intersection of I-70 and Goodfellow Boulevard (Figure 1). It is adjacent to the northern part of the Sverdrup U.S. Army Reserve Center (Facility ID MO028) at 4301 Goodfellow Boulevard in St. Louis. The 89th Regional Readiness Command (RRC) owned the former Hanley Area until it was disestablished in June 2009. The 88th RSC now owns the area and occupies the Center.

The site consists of a relatively flat terrace that slopes steeply down to Goodfellow Boulevard to the east and Stratford Avenue on the north. The site elevation ranges from 532 to more than 558 feet above mean sea level (amsl). Elevation changes by more than 18 feet between the northern part of the site and Stratford Avenue (Figure 2).

The St. Louis Ordnance Plant operated from 1941 to 1945 as a small arms ammunition production facility, producing primarily .30- and .50-caliber ammunition. The plant was divided into two areas designated No. 1 (east of Goodfellow Boulevard) and No. 2 (west of Goodfellow Boulevard). Plant Area No. 2 encompassed 27.68 acres. The former Hanley Area consists of the 14.68 acres at the northeastern end of Plant Area No. 2 at the intersection of Stratford Avenue and Goodfellow Boulevard (Figure 2). Production in the former Hanley Area consisted of blending of primary explosives, incendiary compounds, and the tracer charging of .30- and .50-caliber projectiles as part of the assembly of the final product. Powder wells installed in 1941 received wastewater from buildings and magazines until 1945. The powder wells collected sediment before the wastewater was discharged to the sanitary sewer.

From 1945 through 1959, the U.S. Army Adjutant General's Office used some buildings within Plant Area No. 2 to maintain service records. The Department of Defense (DoD) Finance Center used other buildings within Plant Area No. 2 as classrooms.

The Hanley Area is named for Hanley Industries, Inc., which leased the property in 1959 and conducted operations there through 1979. Hanley used the site for research, development, manufacture, and testing of explosives. It produced specialty ordnance and nonordnance devices for the U.S. military and the National Aeronautics and Space Administration. Hanley used most of the buildings to load detonators and primers and to mix explosives. Explosives were dried in magazines by leaving cans of explosives exposed to the air. A lead azide reactor was operated in one of the magazines, the location of which is unknown. Hanley reportedly did not use the powder wells or sumps on the property for wastewater disposal.

The Goodfellow U.S. Army Reserve Center (now the Sverdrup U.S. Army Reserve Center) was established on the remaining 13 acres of Plant Area No. 2. Some of the western parts of that area were transferred to the U.S. Department of Labor and are occupied by the Job Corps Training Center. Most of the Hanley Area housed various warehouse buildings, bunkers, and related buildings. Between 2004 and 2007, a contractor demolished buildings and bunkers, except for Buildings 219A, 219D, 219G, and 236, for the 89th RRC, the former property owner. According to the 88th RSC, Buildings 219A, 219D, and 236 are used for storage. Building 219G is occupied during business hours, and the site is completely fenced (partially with iron fencing, the balance with a 6-foot-tall chain-link fence).

The site contains underground rooms (basements and bunkers), tunnels for service utilities, and a combined underground wastewater and stormwater collection system. The underground structures are intact. According to the October 2001 Preliminary Assessment/Site Inspection Report (TapanAm 2001), very little water was

observed in the tunnel system south of former Building 220. The floor of the tunnels is 10 to 12 feet below ground (U.S. Army Toxic and Hazardous Materials Agency 1991).

Offsite Properties

Job Corps Training Center West of the Former Hanley Area. The Job Corps Training Center lies west of the site. Buildings on Job Corps property consist of student dormitories, a gymnasium, several buildings for student training/education, and administrative buildings. The Job Corps buildings immediately adjacent to the north part of the former Hanley appear to consist of a small welding shop (depicted as Building 224—Transformer Station in Figure 2), and a student dormitory.

Residential Properties North of the Former Hanley Area. Residential properties north of the former Hanley Area, across Stratford Avenue, are designated as a "neighborhood preservation area" by the St. Louis Planning and Urban Design Agency (2009). Parcels north of the former Hanley Area that lie along Goodfellow Boulevard are designated as a "neighborhood commercial area" (St. Louis Planning and Urban Design Agency 2009). Twenty-nine single-family raised ranch-style homes are located north of the former Hanley Area within a block defined by Stratford Avenue to the south, Goodfellow Boulevard to the east, Henner Avenue to the north, and Irving Drive to the west (Figure 3). Walk-out basements were noted during previous investigations at several residences north of the former Hanley Area. Each residence is situated on lots that are generally less than 0.15 acre.

Day Care Center and Adjacent Nonresidential Properties North of the Former Hanley Area. A day care center is present on the north side of Henner Avenue at its intersection with Goodfellow Boulevard (Figure 3). The building footprint is approximately 3,500 square feet. Based on building permits issued by the City of St. Louis[1], the day care center at 4725 Goodfellow Boulevard has been in operation since at least 1997.

The day care center lies adjacent to the following commercial and industrial properties to the north, south, and east:

- A car wash/auto repair shop (4729 Goodfellow Boulevard) is immediately to the north of the day care center and northeast of the former Hanley Area. A review of St. Louis building permits indicate that the property has operated as an auto repair shop since at least 1999.
- A restaurant, Goodfellow Chop Suey (4719 Goodfellow Boulevard), lies south of the day care center, across Henner Avenue, and northeast of the former Hanley Area. A review of St. Louis building permits indicates that the property was formerly operated as a convenience store (Goodfellow Quick Shop).
- The St. Louis Army Ammunition Plant (SLAAP) is a 21-acre industrial area that lies across Goodfellow Boulevard, east of the day care center and northeast of the former Hanley Area. A search of MDNR's online records[2] indicates that an underground storage tank site lies on the SLAAP site. During its review of the OU-2 UFP-QAPP, MDNR notified the Army that the underground storage tank was removed and closure was completed.

Site Characteristics

Climate

Weather conditions in the St. Louis area vary widely, because of the alternating passage of warm, moist air masses from the Gulf of Mexico and cold, dry air masses from the arctic. During the summer, hot, moist air dominates, with an average temperature of 77 degrees Fahrenheit, and 37 days with highs over 90 degrees Fahrenheit. Winters are cold, with an average temperature of 33 degrees Fahrenheit and an average of 18 inches of snowfall a year. Winter is the driest part of the year, with an average of 6 inches of precipitation. Spring is the wettest, with an average precipitation of 10.5 inches. The annual precipitation

[1] http://dynamic.stlouis-mo.gov/addressSearch/

[2] http://www.dnr.mo.gov/internetmapviewer/makemap.map?select=ws17,NRDSDEP4.WASTE.BLW_GRD_TANKS.OBJECTID,3277

average for St. Louis is 33.8 inches (National Oceanic and Atmospheric Administration 2007). According to data provided by the National Climatic Data Center, average annual wind speed in the St. Louis area is 10 miles per hour, with a prevailing wind direction of west-northwest (National Climatic Data Center 1998).

Topography

The site and adjacent properties are located in northern St. Louis, which lies in the dissected till plains region of the Central Lowlands Physiographic Province (Miller et al. 1974). Topography of the Dissected Till Plains Province is gently sloping, with elevations ranging from 500 to 700 feet amsl. Local slopes are the result of dissection of the plains and the general dip of the plain, which is to the northeast.

The former Hanley Area consists of a relatively flat terrace, which slopes steeply down to Goodfellow Boulevard to the east and Stratford Avenue on the north. There is evidence of grading, with high points cut and low areas filled to generally level the site. Based on survey data collected at the site, the elevations there range from 532 to more than 558 feet. An elevation change (greater than 18 feet) occurs between the northern part of the site and Stratford Avenue.

Based on observations made during previous investigations conducted at the former Hanley Area, the surface topography immediately north of the former Hanley Area is relatively flat. The topography slopes gently upward to the west between Stratford Avenue and Goodfellow Boulevard and slopes downward to the west near the intersection of Stratford Avenue and Irving Street (Figure 3). The topography is relatively flat to the north between Stratford and Henner Avenues.

Geology

Overburden soils at the site consist primarily of lean clay. The soil lithology is relatively consistent across the site. Fill material, including gravel, concrete rubble, brick debris, and sand were observed in portions of the site as deep as 11 feet. Figure 4 shows the location of the cross section depicted in Figure 5.

Lean clay was observed roughly 20 to 25 feet below ground (514.2 to 509.3 feet amsl in elevation) in the north part of the former Hanley Area. Discontinuous lenses of silt were observed within the lean clay. A fat clay layer with discontinuous lenses of lean clay was observed to roughly 43 feet below ground at MW-115, decreasing in thickness to the north until pinching out near MW-108. The fat clay layer was observed at roughly 22 feet below ground at MW-117, 21 feet below ground at MW-107, 25 feet below ground at MW-108, and 25.5 feet below ground at MW-109. A hard, dry, completely weathered shale with discontinuous lenses of silt and clay underlies the clay.

The weathered shale is defined as considerably weakened rock that may behave as a soil but retains relict texture (Geological Society Working Group 1995). The discontinuous lenses of silt and clay within the weathered shale are likely the result of differential weathering along bedding planes, based on visual observations during the 2008 field investigation in the north part of the former Hanley Area. The thickness of the weathered shale ranges from 6 to 12 feet in boreholes advanced to depths at which the competent bedrock was encountered (MW-116 and MW-117). Competent shale was encountered in well MW-116 at 34.0 feet below ground (500.3 feet amsl in elevation) and in MW-117 at 38.3 feet below ground (503.1 feet amsl in elevation). When the soil boring at MW-117 was advanced, a coal layer roughly 6 inches thick was observed at 45 feet below ground (496.4 feet amsl).

Hydrogeology

Groundwater is present within more permeable silt and clay lenses that are locally discontinuous within the upper clay (lean clay) unit. The depth to groundwater within the lean clay is less than 1 foot below ground at monitoring well MW-110 to more than 24 feet below ground upgradient of former Building 220.

Saturated conditions were not observed within the weathered shale underlying the clay unit. Groundwater was encountered in a 6-inch saturated coal layer within the competent shale zone. Groundwater within the coal does not appear to be hydraulically connected to groundwater observed in the discontinuous silt and clay lenses. In December 2011, the groundwater level measured in MW-117, screened within competent shale, was

roughly 4.4 feet lower than the groundwater level measured in MW-111, located 4 feet west of MW-117 and screened in the overburden clay.

As shown in Figure 6, groundwater generally flows from the south and west to the northeast. The groundwater level measurements collected during the 2008 RI indicate that the horizontal groundwater gradients range from 0.054 to 0.019 foot per foot in the northern part of the site and from 0.048 to 0.010 foot per foot in the southern part. The gradients generally reflect those reported in the 2007 soil and groundwater remedial investigation (USACE 2007). Based on a geotechnical analysis of site soils during the 2008 RI, the hydraulic conductivity in the lean and high-plasticity clay is relatively low, ranging from 1×10^{-5} to 10^{-7} centimeters per second). Using an assumed porosity of 30 percent, the lowest and highest hydraulic gradients (0.019 and 0.054 foot per foot), and the lowest and highest measured hydraulic conductivities (2.3×10^{-7} and 3.1×10^{-5} cm/s) determined by ASTM International (ASTM) D5084, the calculated groundwater velocity ranges from 0.79 to 5.77 feet per year (CH2M HILL 2009). Groundwater flow direction will be further investigated because of the limited monitoring network northwest of the former Hanley Area.

In 2012, the Army conducted a transmissivity test on a monitoring well with the highest apparent yield (based on previous purging records) to determine if the aquifer at the former Hanley Area is capable of producing 150 gallons per day, which USEPA considers as the minimum yield required to supply the needs of an average-sized household (USEPA 1988a). Because MW-114 could not yield 75 gallons over a 12-hour period during the pump test, it was concluded that MW-114 is not capable of yielding 150 gallons over a 24-hour period. Based on the Class IIIA groundwater classification and results of the transmissivity test at MW-114, potable use is not considered a complete exposure pathway for groundwater.

Current and Potential Future Site and Resource Uses

The former Hanley Area consists of 14.68 acres and is used for industrial purposes. Onsite buildings and bunkers have been demolished, with the exception of Buildings 219A, 219D, 219G, and 236. According to the 88th RSC, only Building 219G is occupied. Buildings 236, 219A, and 219D are used for storage only. Building 219G is occupied during business hours, and the site is completely fenced (partially with iron fencing and the remaining with a 6-foot-tall chain-link fence).

The site is bordered by the Job Corps facility on the west and residential areas to the north, west, and southwest. The area to the east was formerly part of the St. Louis Ordnance Plant and is now owned by the General Service Administration. The 89th RRC owned the former Hanley Area until the 89th RRC was disestablished in June 2009. The 88th RSC now owns the site and occupies the Sverdrup U.S. Army Reserve Center south of the site. According to the City of St. Louis Zoning Department and Assessor's Office, the St. Louis Ordnance Plant encompasses 125 acres and includes the Job Corps facility to the west of the former Hanley Area and Plant No. 2, and the property east of Goodfellow Boulevard (Plant No. 1). The entire site, as described by the Zoning Department, is zoned industrial, commercial, and residential.

In 2005, the St. Louis Planning Commission adopted a strategic land use plan for the City of St. Louis. The plan provides a roadmap for future development. It identifies established neighborhoods, historic districts, and business areas that the City intends to maintain and enhance. It also identifies areas where future development and land use changes are encouraged. The St. Louis Strategic Land Use Plan identifies the former Hanley Area as a "business and industrial development area." Neighboring parcels to the south and east are similarly designated. Residential properties to the north of the former Hanley Area, across Stratford Avenue, are designated as a "neighborhood preservation area." Parcels north of the former Hanley Area that lie along Goodfellow Boulevard are designated as a "neighborhood commercial area" (St. Louis Planning and Urban Design Agency 2009). Although the General Services Administration and 88th RSC do not have immediate plans for developing the property, the City of St. Louis has expressed interest in obtaining and redeveloping the former Hanley Area in the future.

City-supplied drinking water is provided to residents and industries in the area. The city draws water from the Mississippi River from intakes upstream of the site. At its closest point, the Mississippi River is located about 3 miles from the site. City of St. Louis Ordinance 66777 prohibits the use or attempted use of groundwater as a

potable water supply and the drilling or installation of wells for a potable water supply within the corporate limits of the City of St. Louis. Groundwater beneath the former Hanley Area is Class IIIA, meaning it is not a source of drinking water based on insufficient yield, as discussed in Appendix A of the decision document for OU-1 (CH2M HILL 2011a).

Investigation History

Environmental investigations at the former Hanley Area have been conducted since 1979. In 2008, CH2M HILL performed an RI to fill remaining data gaps and to delineate the nature and extent of contamination at the site. Results from the 2008 RI and previous investigations were presented and discussed in the RI report (CH2M HILL 2009), which also presents human health and ecological risk assessment findings. Reports documenting previous environmental investigations are available in the administrative record file for the former Hanley Area, which is maintained at the Julia Davis Branch Library, 4415 Natural Bridge Avenue, St. Louis, and is available for public review.

2008 RI

The RI identified metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons in various media at concentrations exceeding conservative screening levels. The Army addressed unacceptable risks associated with these chemicals in an OU-1 remedial action in 2012 described later in this worksheet. Because metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons were addressed under OU-1, the chemicals are not discussed in detail in this UFP-QAPP. Details regarding metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons are provided in the RI report (CH2M HILL 2009).

Results from the 2008 RI revealed dissolved-phase groundwater VOC contamination in the northern part of the former Hanley Area. The apparent source of VOCs is the former Building 220 in the northern part of the site. The contamination consists of three distinct plumes comprising one or more chlorinated VOCs. In addition, other VOCs were detected at concentrations above screening levels in isolated occurrences within and around the plumes. Results from the 2008 RI and subsequent investigations are presented in Figure 7. Table 10-1 summarizes the monitoring well construction details for the existing monitoring wells.

Plume A. Tetrachloroethene (PCE), TCE, and *cis*-1,2-dichloroethene (DCE) make up Plume A. Spent product likely was discharged into the sewer inlets on the southwest and northeast sides of the concrete loading slab at the northeast corner of former Building 220. The sewer system downgradient and northeast of former Building 220 is suspected to be the primary source of Plume A. The presence of TCE and *cis*-1,2-DCE may be attributed to reductive dechlorination of PCE. There is no historical record of a single large spill, but sporadic discharge of small quantities of spent product is assumed to have occurred. There is no known continuing source of PCE. The depth of contamination is just below ground to the weathered shale interface at roughly 26 to 28 feet below ground.

Plume B. 1,2-DCA is encountered in Plume B, which is largely commingled with Plume A. The source of 1,2-DCA in soil and groundwater is likely attributable to laboratory and maintenance shop activities conducted at former Building 220. 1,2-DCA was used as a degreaser, paint remover, and as a constituent in scouring compounds (Agency for Toxic Substances and Disease Registry 2005). Spent product likely was discharged into the sewer inlets on the southwest and northeast sides of the concrete loading slab at the northeast corner of former Building 220. Based on the location of 1,2-DCA in groundwater, leaks in the sewer system may have contributed to the vertical and lateral migration of the contaminant, but they have not been clearly identified as the potential point of release. There is no known continuing source of 1,2-DCA. The depth of contamination is just below ground to the weathered shale interface at roughly 24 to 30 feet below ground.

During the 2010 predesign groundwater investigation (CH2M HILL 2011b) and subsequent groundwater sampling events, 1,2-DCA was found in MW-106 and MW-107 at concentrations exceeding screening levels. The exceeding concentration in MW-107 falls outside of the Plume B footprint shown in Figure 7. The Army will further assess groundwater conditions in the area along Stratford Avenue as described in this UFP-QAPP.

Plume C. Plume C, southwest of former Building 220, consists of commingled carbon tetrachloride (CT), chloroform, and TCE. The source of Plume C is unknown. CT and TCE appear to be the original constituents of the plume, with chloroform present as a breakdown product of CT. The TCE does not appear to have degraded anaerobically, as indicated by the lack of daughter products such as *cis*-1,2-DCE and vinyl chloride. The extent of the plume is small but may not be fully delineated to the west and east. Groundwater samples collected during the July and November 2012 OU-1 long-term management (LTM) groundwater sampling events at monitoring well MW-118, within the core of the commingled CT and TCE plume, indicate CT and TCE concentrations above the remediation goal for CT and above the risk-based threshold for TCE that were established in the OU-1 decision document (CH2M HILL 2011b). Plume C has been delineated to the north and south by monitoring wells MW-114 and MW-115, respectively. The depth to groundwater is greater than 10 feet, which is the maximum depth at which the groundwater direct contact pathway for construction workers is considered complete. Contamination lies between the groundwater table to the overburden/weathered shale interface at roughly 34 feet below ground.

The finding of VOCs in groundwater prompted the Army to perform several investigations of VI pathway as summarized in the following subsection.

VI Investigations

The VI pathway was first investigated during the 2008 RI. In March 2008, groundwater samples were collected from groundwater sampling points at residential properties north of Stratford Avenue: 6321, 6317, and 4701 (Figure 7). Attempts were made to collect soil gas samples from several locations at select residences along Stratford Avenue. The tight expansive clays prevented soil gas from being drawn through the soil. After deliberation with USACE and MDNR on March 21, 2008, it was determined that soil gas could not be collected at the site due to tight expansive clays.

One-inch temporary piezometers were installed near the south side of two residences along Stratford Avenue and near the south side of one residence located along Goodfellow Boulevard. Groundwater was expected to be encountered at approximately 7 to 10 feet below ground; however, saturated conditions were not encountered at this depth. Therefore, the temporary piezometers were installed at depths between 25 and 30 feet below ground. Groundwater grab samples were analyzed for VOCs, including the following chlorinated VOCs of interest: PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, vinyl chloride, and 1,2-DCA. VOCs were not detected in groundwater samples, and they were not measured above VI screening levels.[3]

Indoor and outdoor air samples were collected from one residence—Private Property 2 (PP-2; Figure 3) in March and May 2008. The residence was selected for indoor and outdoor air sampling because it is directly in the path of potential contamination migration and is vacant, which reduces the risk of contamination from outside sources. Indoor and outdoor air samples were analyzed for the following chlorinated VOCs of interest: PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, vinyl chloride, and 1,2-DCA. Three constituents (1,2-DCA, PCE, and TCE) were found at concentrations above the USEPA Region 6 medium-specific screening levels (MSSLs) for ambient air in samples collected from the basement or in both the basement and outdoor air. Only the indoor air sample exhibited a TCE concentration greater than 1 microgram per cubic meter ($\mu g/m^3$), which was selected as the low end of the acceptable risk level (between 1 and 10 $\mu g/m^3$) during a discussion between the Army, MDNR, and USEPA on April 22, 2008. Based on the result, an additional round of air samples was collected during the RI in May 2008. Results from the May 2008 indoor and outdoor air samples indicated that risk due to VI were not above regulatory targets at PP-2 at that time.

A predesign groundwater investigation was performed in August 2010. Groundwater samples were collected from onsite and offsite monitoring wells and analyzed for VOCs. At MW-107, 1,2-DCA was measured at 22.7 µg/L, exceeding the maximum contaminant level of 5 µg/L. Because MW-107 is located within 50 feet of PP-1, the Army and regulatory stakeholders agreed to perform a VI assessment at PP-1 consisting of indoor air,

[3] VISLs are available at the following USEPA Web site: http://www.epa.gov/oswer/vaporintrusion/guidance.html#Item6.

outdoor air, and subslab soil gas sampling. The stakeholders agreed that VI sampling would be performed at PP-2, PP-3, and PP-4 contingent upon the results from PP-1. In addition, P-17 was investigated at the request of a resident in response to a public meeting notification letter sent by the 88th RSC in November 2010. Both PP-1 and PP-17 were sampled in May 2011. Because the Army was able to collect subslab soil gas samples from the residence, the Army initiated requests to the property owners to collect samples at PP-2, PP-3, and PP-4.

CH2M HILL performed VI assessments between May 2011 and June 2012 at the following residences shown in Figure 3:

- PP-1 (May 2011, December 2011, and June 2012)
- PP-2 (February 2012)
- PP-3 (February 2012)
- PP-17 (May 2011 and December 2011)

Each VI assessment consisted of completing building surveys and chemical inventories, subslab soil gas sampling, and indoor and outdoor air sampling (Figure 3). Groundwater grab samples were collected in the back yard and front yard of PP-17, and a HAPSITE investigation was conducted in PP-1.

A third attempt was made to sample PP-17 in June 2012. However, the resident was unable to commit to a specific time in which the sampling team could enter the residence, so the assessment could not be performed. PP-4 could not be sampled due to lack of response to ROE request letters.

Groundwater, subslab soil gas, and indoor air samples were analyzed for the following VOCs that exceeded the historical drinking water USEPA Region 6 MSSLs during the 2008 RI:

- Benzene
- CT
- Chloroform
- 1,2-DCA
- *cis*-1,2-DCE
- *trans*-1,2-DCE
- Methylene chloride
- Naphthalene
- 1,1,1,2-tetrachloroethane (TeCA)
- 1,1,2,2-TeCA
- 1,1,2-trichlroethane (TCA)
- PCE
- TCE
- Vinyl chloride

The MSSLs were subsequently compared with and determined to be lower than the USEPA VISLs. 1,1,1,2-TeCA was not included in the analyte list for subslab soil gas and indoor air and outdoor air samples because it is not reported in the analyte list for Method TO-15 nor the Compendium Method TO-15 (USEPA 1999), which adds compounds to the original Method TO-15. The omission of 1,1,1,2-TeCA in the reporting list is not considered a data gap because the chemical has not been detected in any offsite groundwater samples. The detectable presence of 1,1,1,2-TeCA was limited to one monitoring well, MW-111, located within the site boundaries of the former Hanley Area, which has since been treated by soil mixing with zero-valent iron during the OU-1 remedial action. Methylene chloride (degradation product of CT) was added at MDNR's request during the FS.

Results of the VI assessments are provided in technical memoranda for each respective residence, as presented follows:

- May 2011 VI Assessment at PP-1, St. Louis, Missouri
- May 2011 VI Assessment at PP-17, St. Louis, Missouri
- December 2011 VI Assessment at PP-1, St. Louis, Missouri
- December 2011 VI Assessment at PP-17, St. Louis, Missouri
- February 2012 VI Assessment at PP-2, St. Louis, Missouri
- February 2012 VI Assessment at PP-3, St. Louis, Missouri
- June 2012 VI Assessment at PP-1, St. Louis, Missouri

Based on VI assessments performed at PP-1 in May 2011, December 2011, and June 2012, contamination from the former Hanley Area does not appear to be contributing to VI and further near-term VI monitoring at PP-1 was deemed not warranted. Based on the results of the OU-2 RI, the Army will consider additional VI

monitoring at PP-1 if the investigation indicates a potential connection between the former Hanley Area and subslab soil gas beneath PP-1.

Additional VI assessments at PP-2 and PP-3 are needed to further assess whether contamination from the former Hanley Area may be contributing to potential VI at the residences and to assess temporal variability, which is consistent with USEPA (2002) VI guidance.

Figure 7 presents VOCs in groundwater at concentrations detected above VISLs.

Site Removal and Remedial Actions

Prior to the 2012 OU-1 remedial action, no remedial actions at the St. Louis Ordnance Plant had occurred. However, decontamination efforts, removal of a leaking transformer, and demolition of buildings, bunkers, and magazines have been completed throughout the site's operational history.

To identify and implement appropriate remedial actions for site contamination and human health risks identified in the 2008 RI, the Army followed the CERCLA process as described in the following subsections.

Feasibility Study

An FS was performed to develop and evaluate remedial alternatives that address potential unacceptable risks to human health and the environment identified in the RI, and to meet applicable or relevant and appropriate requirements. Remedial action objectives were established based on regulatory requirements, standards, and guidance. Preliminary remediation goals were developed based on regulatory requirements, standards, and guidance to meet the site-specific Remedial action objectives. General response actions were identified for the site to develop remedial alternatives. Based on the risks present at the site, the following alternatives were developed:

- Alternative 1, No Action
- Alternative 2, In Situ Groundwater Treatment using Thermal Technologies, Soil and Powder Well Sediment Removal, and Offsite Disposal
- Alternative 3, In Situ Groundwater Treatment and Soil and Powder Well Sediment Removal and Offsite Disposal
- Alternative 4, Groundwater Source Removal by Excavation, Soil and Powder Well Sediment Removal, and Offsite Disposal

The alternatives were evaluated against seven feasibility evaluation criteria as defined in the National Contingency Plan and CERCLA (CH2M HILL 2010).

Proposed Plan

The proposed plan for the former Hanley Area was released for public comment on November 29, 2010. The 30-day public comment period ended on December 29, 2010. The proposed plan identified in situ groundwater treatment using chemical processes as the preferred alternative for groundwater remediation and soil mixing and soil and powder well sediment removal with offsite disposal as the preferred alternative for soil remediation.

A public meeting regarding the proposed plan was held on December 13, 2010, at the Julia Davis Branch Library in St. Louis, Missouri. Information regarding the site and the remedy was available at the public meeting, and representatives from the Army, MDNR, and USEPA were present to answer questions from the public. No comments were received from the public during the public comment period or at the public availability session.

OU-1 Decision Document

During development of the decision document, the Army divided the remedy at the former Hanley Area into two OUs in consultation with MDNR and USEPA:

- OU-1: Actions Addressing Contaminated Soil, Powder Well Sediment, and Groundwater Concerns
- OU-2: VI Pathway

The decision document for OU-1 was signed by USAEC on September 26, 2011. The selected remedy for OU-1 would address areas of soil and groundwater contamination that potentially posed unacceptable risks to human health. It consisted of the following components: soil removal and offsite disposal; removal and offsite disposal of sediment (if sediment is observed) at 22 powder well locations; in situ groundwater treatment using chemical processes and soil mixing—Plume A; groundwater monitoring within Plume C in an area contaminated with CT; LUCs; and five-year performance reviews. Remediation goals for soil and groundwater were identified in the decision document. Remediation goals were not developed for the powder well sediment during the FS because all of the sediment would be removed from the powder wells.

OU-1 Remedial Action

The selected remedy for OU-1 consisted of the components summarized in the following paragraphs. Construction activities associated with the OU-1 remedial action are described in the Interim Remedial Action Completion Report (CH2M HILL 2012a).

Soil removal and offsite disposal. During the RI phase, MDNR, MDHSS, USEPA, and the Army agreed that certain areas of surface soil with elevated arsenic, lead, and Aroclor 1260 concentrations would be removed during the remedial action. Additional areas of surface soil contaminated with thallium were identified during the FS phase and were also removed during the remedial action. Soil removal and offsite disposal were completed in 2012.

Removal and offsite disposal of sediment at 22 powder well locations. Twenty-two of the 23 powder wells were located during the remedial action. Sediment, debris, and liquids were removed from the powder wells, characterized, and disposed of. Small arms ammunition was recovered from one of the powder wells and transported offsite for disposal. Except for PW2, which could not be located in the field, each powder well was filled with clean imported fill.

In situ groundwater treatment using chemical processes and soil mixing—Plume A, an area contaminated with PCE. The area of groundwater contamination posing an unacceptable risk to construction workers was treated by applying a chemical reductant, zero-valent iron, to soil and groundwater in place. Mechanical mixing of the soil was performed to distribute the chemical amendment throughout the soil column within the treatment zone.

Groundwater monitoring within Plume C, an area contaminated with CT. Data from groundwater monitoring will confirm that the exposure pathway between construction workers and contaminated groundwater remains incomplete because the depth to the groundwater table is greater than 10 feet below ground.

LUCs. LUCs will be implemented to address the following potential risk that is not being immediately mitigated by other components of the selected remedy: construction worker direct contact with groundwater CT concentrations exceeding the remediation goal in excavations within the Plume C footprint. The remediation goal for CT was established in the OU-1 decision document (CH2M HILL 2011b). As stated above, remedial action objectives associated with Plume A were addressed using chemical processes and soil mixing.

LUCs will be established over the Plume C footprint as long as CT concentrations remain above the groundwater remediation goal. The LUCs will prohibit construction activities below the groundwater table without proper health and safety training and personal protective equipment.

Five-year performance reviews. Five-year performance reviews will be conducted as long as hazardous substances remain at the site at concentrations that do not allow unlimited use/unrestricted exposure, per the National Contingency Plan. Site-specific conditions for achieving unlimited use/unrestricted exposure are provided in Section 3.4 of the LTM/LUC Implementation Plan (LUCIP; CH2M HILL 2012c). Once the conditions have been met, the Army will recommend terminating the five-year reviews, in consultation with MDNR and USEPA and subject to approval by MDNR, the lead regulatory agency. Once MDNR approves of terminating the five-year reviews, the basis for termination will be documented in a final five-year review report.

The five-year review will consider all complete exposure pathways and chemicals of concern (COCs) that remain above unrestricted use concentrations. The five-year review will also assess the effectiveness of LUCs in protecting against onsite residential and industrial worker exposure to groundwater COCs.

Vapor Intrusion Pathway

The OU-1 remedial action addressed concerns related to soil, powder well sediment, and groundwater. However, further investigation of shallow groundwater, indoor air, outdoor air, and subslab soil gas is needed to assess whether site-related VOCs in groundwater are potentially migrating into subslab soil gas beneath offsite structures, resulting in current or future indoor air impacts from VI. A conceptual site model cross section showing the possible VI pathway is depicted in Figures 8 and 9. Characterizing this potential pathway is the primary objective of the OU-2 RI.

TABLE 10-1

Permanent Monitoring Well Construction Summary

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Well/ Piezometer	Date Installed	Well Diameter (inches)	Total Depth (ft bgs)	Surface Elevation (feet)	Riser Elevation (feet)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Bentonite Interval (ft bgs)	Grout Interval (ft bgs)
MW-106	01/22/05	2	35	545.26	544.93	15.0–35.0	12.0–35.0	7.0–12.0	3.0–7.0
MW-107	01/25/07	2	27	532.11	531.76	10.0–27.0	8.0–27.0	5.0–8.0	3.0–5.0
MW-108	01/25/07	2	27	534.48	534.17	10.0–27.0	8.0–27.0	5.0–8.0	3.0–5.0
MW-109	01/26/07	2	28	536.65	536.35	10.0–28.0	8.0–28.0	5.0–8.0	3.0–5.0
MW-110	01/25/07	2	28	534.97	534.67	10.0–28.0	8.0–28.0	5.0–8.0	3.0–5.0
MW-112	01/25/07	2	28	534.22	533.49	10.0–28.0	8.0–28.0	5.0–8.0	3.0–5.0
MW-113	01/26/07	2	27	537.75	537.25	10.0–27.0	8.0–27.0	5.0–8.0	3.0–5.0
MW-114	03/20/07	2	29	543.75	543.41	9.0–29.0	7.5–29.0	5.5–7.5	2.0–5.5
MW-115	05/19/08	2	43	557.64	560.66	33.0–43.0	31.0–43.0	29.0–31.0	0.0–29.0
MW-116	05/16/08	2	28	534.29	533.91	18.0–28.0	16.0–28.0	14.0–16.0	0.0–14.0
MW-118	08/11/10	2	36	553.55	553.31	26.0–36.0	24.0–36.0	22.0–24.0	1.0–22.0
MW-119	05/09/12	2	30	542.15	541.63	10.0–30.0	8.0–30.0	0.0–8.0	—

Note: MW-106 completed with concrete from 0.0–3.0 ft bgs; MW-107 through MW-110, MW-112, and MW-113 completed with concrete from 0.0–2.5 ft bgs and fine sand from 2.5–3.0 ft bgs; MW-111 and MW-114 completed with concrete from 0.0–2.0 ft bgs.

— = Interval not completed with the specified material.

ft bgs = feet below ground surface

Worksheet #11—Project/Data Quality Objectives

Project Quality Objectives

Project quality objectives (PQOs) define the type, quantity, and quality of data that are needed to answer project-specific questions and support project specific decisions. The PQOs were developed during the work planning process, which included project stakeholders, as discussed in Worksheet #9.

Who will use the data?

Army stakeholders (88th RSC, USAEC, and USACE), MDNR, USEPA, and CH2M HILL, will use the data to support the project-specific decisions to be made, as outlined in the Worksheet #11 tables (below) and to support the project conceptual site model, as defined in Worksheet #10.

What will the data be used for?

The data will be used to evaluate the VI pathway at the former Hanley Area and select properties offsite to determine if additional properties to the north require further investigation. More specifically, the OU-2 RI phase of the data will provide information regarding site-related VOC concentrations in groundwater at the former Hanley Area and in groundwater, subslab soil gas, and indoor air at properties north of the former Hanley Area. Medium-specific data uses are as follows:

- Utilize static water levels in groundwater monitoring wells to refine the potentiometric surface map, providing an improved understanding of groundwater flow direction and gradient.
- Evaluate groundwater analytical data to determine if site-related VOC concentrations exceed VISLs.
- Further evaluate subslab soil gas and indoor air analytical data to determine if concentrations exceed VISLs.
- Assess whether VOCs in subslab soil gas and indoor air are potentially related to releases from the former Hanley Area. To assess possible sources of indoor air and subslab soil gas concentrations detected above residential VISLs, the following lines of evidence will be considered:
  - Comparison of chemical concentrations in indoor air samples and subslab soil gas samples. Similar or higher concentrations detected in indoor air samples compared with subslab soil gas samples provide evidence of an indoor or outdoor background source.
  - Comparison of chemical concentrations in indoor air and outdoor air samples. Similar indoor and outdoor air levels indicate outdoor air is the primary source of the measured indoor concentrations.
  - Evaluation of the ratios of chemical concentrations between or within the difference media sampled.
  - Evaluation of chemical sources identified inside the home.
  - Evaluation of chemicals detected in groundwater. The absence in groundwater of a VOC detected in subslab or indoor air samples provides suggestive evidence that groundwater is not the source.
- Assess whether VOCs in indoor air in the main tunnel system (nearest Plume C and upgradient of Plume C near the property boundary with the Job Corps facility) and in the small utility tunnel located on the west side of former Building 220 are potentially related to releases from the former Hanley Area. To assess possible sources of indoor air concentrations detected above residential VISLs, the following lines of evidence will be considered:
  - Comparison of chemical concentrations in indoor air and outdoor air samples. Similar indoor and outdoor air levels indicate that outdoor air is the primary source of the measured indoor concentrations.
  - Evaluation of the ratios of chemical concentrations between or within the different media sampled.

  - Evaluation of chemicals detected in groundwater. The absence in groundwater of a VOC detected in indoor air samples provides suggestive evidence that groundwater is not the source.

- For groundwater and indoor air, compare current and previous analytical data, where appropriate, to assess temporal trends in VOC concentrations.
- Determine whether groundwater and/or subslab soil gas VOC concentrations warrant a VI assessment on additional properties based on the decision flow diagrams and data quality objectives (DQOs) presented in Worksheet #11 tables.

What types of data are needed?

Groundwater, subslab soil gas, indoor air, and outdoor air samples will be collected and analyzed for a specific target list of VOCs, as defined in Worksheet #15.

The sampling design and rationale is presented in Worksheet #17 (Sampling Design and Rationale). A complete listing of the sample analytes are provided in Worksheet #15 (Reference Limits and Evaluation).

How "good" should the data be in order to support the environmental decision?

Analytical methods are planned to be definitive quality data. Definitive data are defined as data that are suitable for final decision making. The comparison of detected concentrations against screening levels (provided in Tables 15-1 through 15-3) will be used to support the project-specific decisions. Data are generated using rigorous analytical methods, in this case, approved USEPA SW846 reference methods and USEPA vapor analysis methods. Definitive data are not restricted in their use unless quality problems require data qualification resulting in unusable data. Data of definitive quality are needed to evaluate the human health risks.

How much data are needed? Where, when, and how should the data be collected/generated?

Worksheet #17 (Sampling Design and Rationale) describes the field investigation activities planned. Worksheet #18 (Sampling Locations and Methods) summarizes the number of samples and the analytical parameters necessary to assess the VI pathway. Additional data may be needed, based on the decision rules presented in Worksheet #11. Standard operating procedures (SOPs) for field sampling and analytical procedures are discussed in Worksheets #21 (Field SOPs) and #23 (Analytical SOPs). The field SOPs are provided in the field sampling plan (FSP; Appendix C) and the Laboratory SOPs (LSOPs) are provided in Appendix B. Currently, the fieldwork is planned to begin August 2013 and continue through May 2014.

Who will collect and generate the data?

CH2M HILL will collect the data on behalf of USACE. Groundwater samples will be submitted to Empirical Laboratories, Nashville, Tennessee, for analysis and subslab soil gas and indoor/outdoor air samples will be submitted to Applied Sciences Laboratory, Corvallis, Oregon for analysis. All data will be managed by CH2M HILL.

How will the data be reported? How will the data be archived?

Analytical data will be reported in both hardcopy and electronically. Hard copy analytical data will meet reporting requirements defined in Worksheet #29. Electronic data deliverables (EDDs) will follow Stage 2A electronic data deliverable (SEDD) Type 2A formats and imported into automatic data review (ADR) for validation with the project-specific supplied library. The laboratory will verify that the quality, content, and format comply with the latest SEDD requirements.

Hardcopy and electronic data, as well as project records, will be stored by CH2M HILL for 5 years after project completion. Project reports will be archived on CD-ROM or DVD+R media and stored in the project file and available from CH2M HILL.

Data Quality Objectives

The structure of the DQO process provides an effective planning tool that can save resources by making data collection operations more effective and complete to meet overall project objectives.

DQOs are created based on establishing scientifically sound data that will address the overall problem to be solved and include the purpose and media for sample collection, the analytical detection limits (DLs) necessary to support planned data screening or comparisons to appropriate regulatory benchmarks, quality assurance (QA)/QC needs, and knowledge of existing data and project data gaps. Complete DQOs will allow for the end result of the project to address the original problem to be solved to reach a previously agreed upon project closure point.

The DQO process consists of seven iterative steps. Each step defines criteria that will be used to establish the final data collection design. The seven steps are as follows:

1. State the problem to be resolved.
2. Identify the decisions to be made.
3. Identify the inputs to the decisions.
4. Define the boundaries of the study.
5. Develop a decision rule.
6. Specify the tolerable limits on decision errors.
7. Optimize the design for obtaining the data.

Table 11-1 presents six specific project problems and the associated DQOs developed for them.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

DQO #1—Groundwater Investigation Along Stratford Avenue and at PP-17 to Determine if Further Investigation is Warranted
Location:
Along Stratford Avenue, north of the former Hanley Area, and at PP-17
Step 1: Statement of Problem:
From a VI perspective, groundwater VOC concentrations at the water table are of interest because they indicate potential volatilization of chemicals from groundwater to soil gas. Currently, there are no shallow permanent monitoring wells installed along Stratford Avenue to assess groundwater conditions at the water table. The existing monitoring wells are not considered suitable to assess shallow groundwater conditions because the wells terminate at the overburden and weathered shale contact, and the screens are fully submerged.
Step 2: Identify the Decision:
Determine if site-related VOCs in shallow groundwater (at the water table) north of the former Hanley Area along Stratford Ave. and at PP-17 are above VISLs and evaluate if the impacts warrant further action (that is, additional monitoring wells, VI assessment). See DQO #2 for information regarding VI assessments.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 3: Inputs to Decisions:

VISLs for select VOCs in groundwater (reference Worksheet #15).

Validated analytical data from this investigation.

Soil classifications based on geologic logs of each boring completed.

Colocated monitoring well pairs will be installed along Stratford Avenue and at PP-17 to assess groundwater conditions.

Shallow groundwater results will be used to assess the VI pathway. In the event that shallow groundwater is not present in the shallowest water-producing well pair, results from the deep well pair will be used to assess groundwater conditions that may trigger a VI assessment.

Geologic information (soil classifications) and analytical data from previous site investigations will be incorporated into the project decisions.

Groundwater flow direction.

Step 4: Study Boundaries:

The groundwater investigation will be conducted along Stratford Avenue, near PP-1 through PP-8, and at PP-17 (Figure 10). Colocated well pairs will be installed along Stratford Avenue and in the back yard of the residence at PP-17.

Monitoring wells MW-107 through MW-109 terminate at the overburden/shale bedrock contact; therefore, deep wells are not necessary at these locations. Shallow wells will be installed near these locations to complete the well pair.

Temporal boundaries will be assessed by conducting two rounds of groundwater sampling events, separated by at least 6 months.

Step 5: Decision Rules:

Decision rules for this DQO are displayed in a flow diagram provided as Figure 11.

Part 5A –Shallow Groundwater

If information is sufficient to conclude that site-related VOCs detected above VISLs are present in the shallowest water-producing well pairs, then further action will be considered during a meeting with stakeholders (that is, step-out well pair locations) to further assess the VI pathway. With stakeholder input, VI assessments at nearby residences (for example, within a 100-foot radius) will be considered to assess current (indoor air sampling) and future risk (subslab soil gas sampling).

If two consecutive rounds of groundwater sampling , separated by at least 6 months, indicate concentrations below VISLs in the shallowest water-producing well pair (or in deep groundwater if shallow groundwater is not present), further investigation and VI assessments are not warranted.

Part 5B –Deep Groundwater

If the deep wells contain site-related VOCs above VISLs, but the corresponding shallow wells do not, then VI assessments will not be performed at nearby residences because VOCs are not migrating along the water table, and therefore could not contribute to VI.

If groundwater is not present in shallowest water-producing well pairs, groundwater in the deep well may be used to assess the VI pathway.

Groundwater flow direction will be refined using static groundwater levels recorded at the monitoring wells.

Step 6: Limits of Decision Errors:

No statistical sampling methodologies are used for this sampling design.

Proposed locations for colocated monitoring well pairs were identified from information obtained through the conceptual site model. The stakeholders agreed to the proposed locations during the September 19, 2012, strategy meeting held among the Army, MDNR, MDHSS, and USEPA.

Decision errors will be minimized through site understanding obtained from previous site visits, development of the conceptual site model, and adherence to SOPs during well installation and sampling.

Analysis of groundwater samples will provide the necessary data to meet DoD Quality Systems Manual (QSM) Version 4.2 specification for precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS).

The analytical methods will provide the lowest available DLs that will allow for the data to be screened against project action levels and meet risk assessment objectives.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 7: Optimize the Sampling Design:

Sampling Design:

1. Six colocated well pairs will be installed along Stratford Avenue to assess groundwater conditions in the vicinity of PP-1 through PP-8. One well pair will be installed in the back yard of the residence at PP-17 to assess groundwater conditions. Refer to Worksheet #17 for sample design and rationale.

2. The 11 newly installed wells along Stratford Avenue and in the back yard of PP-17 and the existing monitoring wells will be sampled for select VOCs using low-flow techniques and one round of groundwater level measurements will be collected during each sampling event. Two rounds of groundwater sampling of the colocated well pairs will be conducted, separated by at least 6 months to assess temporal variability.

3. During the groundwater sampling events, water quality parameters will be analyzed using field methods for dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, and pH.

Optimization:

The data obtained will be used in stakeholder decision making on any path forward direction for the project, except for pre-agreed triggers, to develop a path of no further action based on site data; see decision rules Step 5 and the flow diagram for DQO #1.

DQO #2—VI Assessments at PP-2 through PP-5 and PP-17

Location:

Offsite residences north of the former Hanley Area

Step 1: Statement of Problem:

Additional VI assessments (for example, subslab soil gas, indoor air, and outdoor air sampling) at PP-2 and PP-3 are needed to further assess whether contamination from the former Hanley Area may be contributing to potential VI at these residences and to assess temporal variability, which is consistent with USEPA (2002) VI guidance.

VI assessments were conducted at PP-17 in response to resident concerns about health-related issues and the possibility that the former Hanley Area was contributing to them. Further assessments are needed to evaluate temporal conditions.

The residence located at PP-4 could not be sampled due to a lack of response to ROE request letters.

Because of the historical groundwater concentrations at monitoring well MW-109 (TCE slightly exceeded the VISL of 1.1 µg/L between April 2007 and December 2011), a VI assessment will be conducted at PP-5 (subject to ROE acceptance), located within 50 feet of MW-109.

Step 2: Identify the Decision:

Determine if VI of site-related VOCs is occurring, and if so, determine if there are VISL-related exceedances at offsite residences.

Determine if VI of site-related VOCs could potentially occur in the future at offsite residences.

Step 3: Inputs to Decisions:

Residential VISLs for select VOCs in subslab soil gas and indoor air.

Validated subslab, indoor air, and outdoor air analytical data from this investigation.

Outdoor air data will be used for comparison with indoor air concentrations to determine if the measured indoor air concentrations are associated with outdoor air infiltration.

Historical analytical data from previous VI assessments (subslab and indoor and outdoor ambient air) at PP-2, PP-3, and PP-17 will be included in the decision making process.

Step 4: Study Boundaries:

The VI assessments will be conducted at PP-2 through PP-5 and PP-17. Multiple rounds of subslab soil gas, indoor air, and outdoor air sampling will be conducted to assess temporal variability.

Temporal boundaries will be assessed by conducting three rounds of VI assessments, separated by at least 3 months.

Up to two temporary subslab soil gas probes will be installed within the basement of PP-4 and PP-5 to assess potential current and future risk to residents from VI (subslab soil gas probes already installed at PP-2, PP-3, and PP-17).

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 5: Decision Rules:

Decision rules for DQO #2 are displayed in a flow diagram (Figure 12).

If information is sufficient to conclude that site-related VOCs are detected above VISLs in subslab soil gas, additional investigations may be considered at adjacent properties. A meeting with stakeholders will be held to discuss the next steps.

Chemical concentrations in subslab soil gas and indoor air will be compared using multiple lines of evidence described in the PQO discussion of Worksheet #11. If site-related VOCs in subslab soil gas are above VISLs and site-related VOCs in indoor air are above VISLs, the residents will be notified, and a meeting with stakeholders will be held to consider possible mitigation actions.

If contaminants from the former Hanley Area are suspected of contributing to VOCs in indoor air, and the concentrations indicate excessive risk as described in the notes in Figure 13, the Army will be prepared to promptly implement an interim remedy at the impacted residences. The decision to implement an interim remedy will be made in accordance with the flow diagram presented in Figure 13.As described in the PQO discussion of Worksheet #11, the ratios of chemical concentrations between or within the difference media sampled will be evaluated.

Chemical concentrations in indoor air and outdoor air will be compared. If site-related VOCs in indoor air are due to outdoor air infiltration (as described in the PQO discussion of Worksheet #11), further action will not be considered.

Chemical sources in the residence (chemical inventory) will be evaluated to determine if these sources are contributing to indoor air quality.

If three rounds of VI assessments do not indicate site-related VOCs in subslab soil gas above VISLs, further action will not be considered.

If three rounds of VI assessments do not indicate site-related VOCs in indoor air above VISLs (when subslab soil gas concentrations are detected above VISLs), further action will not be considered.

If subslab soil gas samples cannot be collected due to low air permeability associated with tight soils or saturated conditions beneath the slab, the condition will be noted and discussed with the stakeholders. Indoor air samples will be collected regardless of the soil conditions and the ability to collect subslab soil gas.

Step 6: Limits of Decision Errors:

No statistical sampling methodologies are used for this sampling design.

Proposed locations for VI assessments were identified from information obtained through the conceptual site model. The stakeholders agreed to the proposed locations during the September 19, 2012, OU-2 strategy meeting held among the Army, MDNR, MDHSS, and USEPA.

Decision errors will be minimized through site understanding obtained from previous site visits, development of the conceptual site model, and adherence to SOPs during the VI assessments.

Analysis of subslab soil gas, indoor air, and outdoor air samples will provide the necessary data to meet DoD QSM Version 4.2 specification for PARCCS.

The analytical methods will provide the lowest available DLs that will allow for the data to be screened against project action levels and meet risk assessment objectives.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 7: Optimize the Sampling Design:

Sampling Design:

1. Up to two temporary subslab soil gas probes will be installed in the basement at PP-4 and PP-5, subject to ROE approval. Temporary subslab soil gas probes are already installed at PP-2, PP-3, and PP-17. The subslab soil gas probes will be sampled during each VI assessment to assess possible future risk to residents from VI.

2. One indoor air and one outdoor air sample will be collected at PP-2 through PP-5 and PP-17 during each VI assessment. Indoor air results will be used to assess possible current risk to residents from VI.

3. Three rounds of subslab soil gas samples will be collected to assess temporal variability.

4. During the first round of VI assessments, a building survey will be completed. During each round of VI assessments, the basement floor and walls will be inspected for signs of damage. Floor drains will also be visually inspected for outward signs of damage. A chemical inventory will be completed during each VI assessment. Barometric pressure and weather conditions will be documented during each VI assessment.

5. Investigations at adjacent properties will be considered, with stakeholder input, if it is determined that site-related VOCs are significant and occurring.

Optimization:

The data obtained will be used to in stakeholder decision-making on any path forward direction for the project, except for pre-agreed triggers to develop a path of no further action based on site data; see decision rules Step 5 and the flow diagram for DQO #2 (Figure 12).

DQO #3—Groundwater Investigation West and East of Monitoring Well MW-118 to Confirm or Refine the Plume C LUC and to Determine if Shallow Groundwater Could Contribute to VI at the Job Corps Facility

Location:

Plume C

Step 1: Statement of Problem:

Under OU-1, CT and TCE concentrations in groundwater (Plume C) were detected above the remediation goal of 3,200 µg/L for CT and the risk-based threshold of 2,320 µg/L for TCE at monitoring well MW-118. The horizontal and vertical extent of CT and TCE are sufficiently delineated to the north and south; however, the extent of Plume C requires further characterization to the west, toward the Job Corps facility, and to the east. Similar to DQO #1, groundwater VOC concentrations at the water table are of interest from a VI perspective because they indicate potential for volatilization of chemicals from groundwater to soil gas. Currently, there are no shallow permanent monitoring wells installed west of MW-118, toward the Job Corps facility, to assess groundwater conditions at the water table.

MW-118 is not considered suitable to assess shallow groundwater conditions because the well terminates at the overburden and weathered shale contact, and the screen is fully submerged.

Step 2: Identify the Decision:

Part 2B –Shallow Groundwater

Determine if site-related VOCs in shallow groundwater west of MW-118 are potentially contributing to VI at the Job Corps facility and evaluate if the impacts warrant further action.

Part 2A –Deep Groundwater

Confirm that the current LUC boundaries at Plume C (under OU-1) are protective of the groundwater direct contact pathway for construction workers or to refine the LUC boundary west and east of MW-118 after the western and eastern plume extents are determined.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 3: Inputs to Decisions:

VISLs for select VOCs in shallow groundwater to determine if a VI assessment is warranted.

Remediation goal for CT and risk-based threshold for TCE in deep groundwater to confirm adequacy of western and eastern LUC boundaries.

Validated analytical data from this investigation.

Soil classifications based on geologic logs of each boring completed.

One colocated monitoring well pair will be installed west of MW-118 to characterize Plume C to the west and to assess groundwater conditions that may trigger VI assessments at the Job Corps facility.

One deep monitoring well will be installed east of MW-118 to characterize Plume C to the east.

Groundwater flow direction will be refined using static groundwater levels recorded at the monitoring wells.

Geologic information (soil classifications) and analytical data from previous site investigations will be incorporated into the project decisions.

Step 4: Study Boundaries:

The groundwater investigation will be conducted west and east of MW-118. One pre-determined colocated well pair is proposed west of MW-118, toward the Job Corps facility, and one deep monitoring well is proposed east of MW-118 (Figure 10).

Temporal boundaries will be assessed by conducting two rounds of groundwater sampling events, separated by at least 6 months.

The western LUC boundary may be extended if the new deep monitoring well pair shows detections of CT above the remediation goal or TCE above the risk-based threshold, indicating that Plume C is not bounded to the west. It will only be completed based on stakeholder consensus.

The eastern LUC boundary may be extended if the new deep monitoring well shows detections of CT above the remediation goal or TCE above the risk-based threshold, indicating that Plume C is not bounded to the east. The LUC boundary will only be changed if needed, and then based on stakeholder consensus.

Step 5: Decision Rules:

Part 5B –Shallow Groundwater

If analytical data indicate that site-related VOCs detected above VISLs are present in the shallowest water-producing well pair, then further action may be considered (that is, step-out colocated well pair location) to further assess the VI pathway. VI assessments at the Job Corps facility (for example, within a 100-foot radius) may be considered to assess current (indoor air sampling) and potential future risk (subslab soil gas sampling).

If analytical data indicate that site-related VOCs in the shallowest water-producing well pair are below VISLs, then VI assessment(s) will not be considered.

Part 5A –Deep Groundwater

If the deep wells contain CT above the remediation goal or TCE above the risk-based threshold for two consecutive sampling events, a stakeholder meeting will be held to consider additional monitoring wells or expansion of the LUC boundaries.

If two consecutive rounds of groundwater sampling indicate concentrations below the remediation goal for CT and the risk-based threshold for TCE in the deep monitoring wells, further investigation is not warranted.

If groundwater is not present in shallowest water-producing well pair to assess groundwater conditions from a VI perspective, groundwater in the deep well may be used to assess the VI pathway.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 6: Limits of Decision Errors:

No statistical sampling methodologies are used for this sampling design.

Proposed locations for the colocated monitoring well pair west of MW-118 and the deep monitoring well east of MW-118 were identified from information obtained through the conceptual site model and the July and November 2012 OU-1 LTM groundwater sampling events. The stakeholders agreed to the proposed colocated monitoring well pair locations during the September 19, 2012, strategy meeting held among the Army, MDNR, MDHSS, and USEPA. The proposed deep monitoring well east of MW-118 was determined following evaluation of the July and November 2012 OU-1 LTM groundwater sampling events.

Decision errors will be minimized through site understanding obtained from previous site visits, development of the conceptual site model, and adherence to SOPs during well installation and sampling.

Analysis of groundwater samples will provide the necessary data to meet DoD QSM Version 4.2 specification for PARCCS.

The analytical methods will provide the lowest available DLs, which will allow for the data to be screened against project action levels and meet risk assessment objectives.

Step 7: Optimize the Sampling Design:

Sampling Design:

1. One colocated well pair will be installed west of MW-118 to confirm or refine the LUC boundary to the west, toward the Job Corps facility, and to assess groundwater conditions from a VI perspective. The deep boring will terminate at the overburden and weathered shale bedrock contact to facilitate installation of the deep monitoring well. The shallow boring will be advanced to facilitate installation of the shallow monitoring well.
2. One deep monitoring well will be installed east of MW-118 to confirm or refine the LUC boundary to the east. The deep boring will terminate at the overburden and weathered shale bedrock contact to facilitate installation of the deep monitoring well at the appropriate depth.
3. During the groundwater sampling events, water quality parameters will be analyzed using field methods for dissolved oxygen, oxidation-reduction potential, specific conductance, and pH. One round of groundwater level measurements will be conducted during each sampling event.

Optimization:

The data obtained will be used to in stakeholder decision making on any path forward direction for the project except for previously agreed upon triggers to develop a path of no further action based on site data.

DQO #4—Groundwater Investigation Near Day Care Center to Determine if a VI Assessment is Warranted

Location:

Day Care Center Approximately 350 feet (1 Block) Northeast of the former Hanley Area

Step 1: Statement of Problem:

During the September 19, 2012 OU-2 strategy meeting, MDHSS discussed the need to collect samples from the day care center located approximately 350 feet (1 block) northeast of the former Hanley Area. The Army acknowledged the preference of MDNR, MDHSS, and USEPA to collect samples near the day care center to assess whether contamination from the former Hanley Area may be impacting the center. The Army agreed to discuss possible VI investigation measures at the day care center.

Step 2: Identify the Decision:

Determine if site-related VOCs in shallow groundwater along Stratford Avenue are above VISLs and evaluate if the impacts warrant action near the day care center.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 3: Inputs to Decisions:

VISLs for select VOCs in groundwater.

Validated analytical data from this investigation

Groundwater results at newly installed shallow colocated well pairs near MW-107 through MW-109 will be used to assess groundwater conditions.

Soil classifications based on geologic logs of each boring completed.

Geologic information (soil classifications) and analytical data from previous site investigations will be incorporated into the project decisions.

Step 4: Study Boundaries:

Current Known Boundaries:

Colocated well pairs along Stratford Avenue. Data from these wells will be used to evaluate the potential need to install well pairs and evaluate groundwater conditions closer to the day care center; see Step 5 Decision Rules. See DQO #1 to note the groundwater evaluation process for the well pairs along Stratford Avenue.

Step 5: Decision Rules:

Part 5A –Shallow Groundwater

If information is sufficient to conclude that site-related VOCs detected above VISLs are present in the shallowest water-producing well pairs that are colocated with MW-107 through MW-109, then a groundwater investigation near the day care center will be performed to assess the VI pathway. If the groundwater investigation near the day care center is deemed necessary, groundwater sampling will be conducted along Henner Avenue, south of the day care center, and in the alley, west of the day care center by installing one colocated well pair along Henner Avenue and two well pairs in the alley, southwest and west of the day care center (Figure 10). Stakeholder consensus is required to install well pairs near the day care center.

If well pairs are installed near the day care center and a groundwater investigation is completed, shallow groundwater results would be used to determine the need for VI assessments at the day care center to assess current (indoor air sampling) and future possible risk (subslab soil gas sampling). See decision statements Step 5, DQO #1.

If analytical data indicate that site-related VOCs in the shallowest water-producing well pairs that are colocated with MW-107 through MW-109 are below VISLs, then a groundwater investigation near the day care center will not be considered.

Part 5B –Deep Groundwater

If the deep wells installed near the day care center contain site-related VOCs above VISLs, but the corresponding shallow wells do not, then VI assessments will not be performed at because VOCs are not migrating along the water table, and therefore could not contribute to VI.

If groundwater is not present in shallowest water-producing well pairs, groundwater in the deep well may be used to assess the VI pathway.

Step 6: Limits of Decision Errors:

No statistical sampling methodologies are used for this sampling design.

Proposed locations for colocated monitoring well pairs were identified from information obtained through the conceptual site model. The stakeholders agreed to the proposed locations during the September 19, 2012 strategy meeting held among the Army, MDNR, MDHSS, and USEPA.

Decision errors will be minimized through site understanding obtained from previous site visits, development of the conceptual site model, and adherence to SOPs during well installation and sampling.

Analysis of groundwater samples will provide the necessary data to meet DoD QSM Version 4.2 specification for PARCCS.

The analytical methods will provide the lowest available DLs, which will allow for the data to be screened against project action levels and meet risk assessment objectives.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 7: Optimize the Sampling Design:

Sampling Design:

See sampling design Step 7 of DQO 1.

Optimization:

The data obtained will be used to in stakeholder decision-making on any path forward direction for the project except for previously agreed upon triggers to develop a path of no further action based on site data; see decision rules Step 5.

If Stratford Avenue colocated well pairs indicate the need and based on Stakeholder consensus, up to three well pairs will be installed along Henner Avenue and in the alley west of the day care center to assess groundwater conditions in the vicinity of the day care center. Up to three deep borings will terminate at the overburden and weathered shale bedrock contact to facilitate installation of the deep monitoring wells. Up to three shallow borings will be advanced to facilitate installation of the shallow monitoring wells. The deep and shallow screens will be installed so that the screened intervals do not overlap. The shallow wells will be installed within 18 inches of the deep monitoring wells. A groundwater evaluation will be conducted as defined in DOQ #1.

DQO #5—Refine Groundwater Flow Direction and Assess Groundwater Conditions Northwest of the Former Hanley Area

Location:

Northwest of the Former Hanley Area

Step 1: Statement of Problem:

During the OU-2 strategy meeting, MDNR recommended installing a colocated well pair further west of the originally-proposed colocated well pairs along Stratford Avenue. This well pair would be used to refine groundwater flow direction and to assess groundwater conditions. The Army agreed to install this additional well pair under the condition that the analytical results would not necessarily trigger the need for additional monitoring wells or VI assessments; that determination would be based on the results from the colocated well pair and others further east (closer to the former Hanley Area).

Step 2: Identify the Decision:

Refine groundwater flow direction.

Assess groundwater conditions.

Step 3: Inputs to Decisions:

VISLs for select VOCs in groundwater (reference Worksheet #15).

Validated analytical data from this colocated well pair.

The well pair will be installed furthest west along Stratford Avenue to refine groundwater flow direction and gradient northwest of the former Hanley Area and to assess groundwater conditions.

Geologic information (soil classifications) and analytical data from previous site investigations will be incorporated into the project decisions.

Groundwater flow direction.

Step 4: Study Boundaries:

One colocated well pair will be installed along Stratford Avenue and will be located west of the well pairs that will be used during the groundwater investigation (refer to DQO #1; Figure 10).

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 5: Decision Rules:

Further investigation will be considered if 1) the refined groundwater flow direction indicates a northwest flow direction component; and 2) if site-related VOCs are above VISLs in the shallowest water-producing well pair (or in deep groundwater if shallow groundwater is not present) immediately east of this well pair.

Part 5A –Shallow Groundwater

Refer to Step 5 Decision Rules for DQO #1 if information is sufficient to conclude that site-related VOCs detected above VISLs are present in the shallowest water-producing well pair.

Part 5B –Deep Groundwater

Refer to Step 5 Decision Rules for DQO #1 if the deep wells contain site-related VOCs above VISLs, but the corresponding shallow wells do not.

Groundwater flow direction will be refined using static groundwater levels recorded at the monitoring wells.

Step 6: Limits of Decision Errors:

No statistical sampling methodologies are used for this sampling design.

Proposed locations for the colocated well pairs were determined and agreed to by stakeholders during the September 19, 2012, strategy meeting held among the Army, MDNR, MDHSS, and USEPA.

Decision errors will be minimized through site understanding obtained from previous site visits, development of the conceptual site model, and adherence to SOPs during well installation and sampling.

Analysis of groundwater samples will provide the necessary data to meet DoD QSM Version 4.2 specification for PARCCS.

The analytical methods will provide the lowest available DLs, which will allow for the data to be screened against project action levels and meet risk assessment objectives.

Step 7: Optimize the Sampling Design:

Sampling Design:

1. One colocated well pair will be installed furthest west along Stratford Avenue to refine the groundwater flow direction near the former Hanley Area.
2. The well pair will be sampled for select VOCs using low-flow techniques and one round of groundwater level measurements will be collected during each sampling event. Based on the results of the western-most proposed well pair to achieve DQO #1, up to two rounds of groundwater sampling may be conducted, separated by at least 6 months to assess temporal variability.
3. During the groundwater sampling events, water quality parameters will be analyzed using field methods for dissolved oxygen, oxidation-reduction potential, specific conductance, and pH.

Optimization:

The data obtained will be used in stakeholder decision-making on any path forward direction for the project, except for pre-agreed triggers to develop a path of no further action based on site data.

If groundwater results in the shallowest water-producing well pair (or in deep groundwater if shallow groundwater is not present) indicate concentrations below VISLs, the well pair will be used for the sole purpose of determining groundwater flow direction and gradient.

DQO #6—Indoor Air Sampling in Tunnel System

Location:

Main tunnel system closest to Plume C; main tunnel system upgradient of Plume C and near the property boundary with the Job Corps facility; and small utility tunnel on the west side of former Building 220.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 1: Statement of Problem:

Under OU-1, CT and TCE concentrations in groundwater (Plume C) were detected above the remediation goal of 3,200 µg/L for CT and the risk-based threshold of 2,320 µg/L for TCE at monitoring well MW-118. At the request of MDNR, tunnel air sampling in the main tunnel system closest to Plume C, in the main tunnel system near the property boundary with the Job Corps facility, and in the small utility tunnel located on the west side of former Building 220, is needed to assess whether contamination from the former Hanley Area may be contributing to indoor air quality, which could potentially affect the adjacent Job Corps facility (based on tunnel system configuration).

Step 2: Identify the Decision:

Determine if tunnel air in the main tunnel system and small utility tunnel is impacted by site-related VOCs, and if so, determine if further investigation is warranted.

Determine if indoor air concentrations of site-related VOCs could potentially affect the adjacent Job Corps facility.

Step 3: Inputs to Decisions:

Residential VISLs for select VOCs in indoor air.

Validated indoor air and outdoor air analytical data from this investigation.

Outdoor air data will be used for comparison with indoor air concentrations to determine if the measured indoor air concentrations are associated with outdoor air infiltration.

Step 4: Study Boundaries:

Based on the accessibility and safety concerns associated with gaining entry into the tunnel system, tunnel air sampling will be conducted closest to Plume C and MW-118 in the main tunnel system; in the small utility tunnel located on the west side of former Building 220 (if feasible, provided that Job Corps grants access approval); and in the main tunnel system near the property boundary with the Job Corps facility (Figure 14). The outdoor air samples will be collected above the location of the tunnel air samples. Two rounds of tunnel air and outdoor air sampling, separated by at least 3 months, will be conducted in the main tunnel system to assess whether further investigation is warranted. One round of tunnel air and outdoor air sampling will be conducted in the small utility tunnel, if feasible and assuming the Army is granted access approval.

Step 5: Decision Rules:

The ability to collect a tunnel sample within 100 feet of Plume C will be determined through site reconnaissance activities before the sampling event.

If information is sufficient to conclude that site-related VOCs are detected above residential VISLs in tunnel air, additional investigations may be considered. A meeting with stakeholders will be held to discuss the next steps.

Chemical concentrations in tunnel air will be evaluated using multiple lines of evidence described in the PQO discussion of Worksheet #11.

As described in the PQO discussion of Worksheet #11, the ratios of chemical concentrations between or within the difference media sampled will be evaluated.

Chemical concentrations in tunnel air and outdoor air will be compared. If site-related VOCs in tunnel air are due to outdoor air infiltration (as described in the PQO discussion of Worksheet #11), further action will not be considered.

Possible chemical sources (chemical inventory) in the tunnel system and in the Job Corps building described as the “Transformer Station” in site figures will be evaluated to determine if these sources are contributing to indoor air quality.

TABLE 11-1
Specific Data Quality Objectives
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Step 6: Limits of Decision Errors:

No statistical sampling methodologies are used for this sampling design.

Proposed locations for tunnel air samples were placed based on proximity to MW-118 (the location of elevated CT and TCE in groundwater); near the property boundary with the Job Corps facility; and in the small utility tunnel on the west side of former Building 220 (if feasible). Outdoor air sampling will be identified through site reconnaissance activities and as close above the location of tunnel air collection as possible.

Decision errors will be minimized through site understanding obtained from previous site visits, historical analytical data, groundwater flow understanding, and adherence to SOPs during air sampling activities.

Analysis of air samples will provide the necessary data to meet DoD QSM Version 4.2 specification for PARCCS.

The analytical methods will provide the lowest available DLs that will allow for the data to be screened against project action levels and meet risk assessment objectives.

Step 7: Optimize the Sampling Design:

Sampling Design:

1. One tunnel air and one outdoor air sample will be collected within 100 feet of Plume C and MW-118, within the main tunnel system. Results will be used to assess whether further investigation is warranted.
2. One tunnel air and one outdoor air sample will be collected further south of Plume C and MW-118, near the property boundary with the Job Corps facility, to assess whether contamination from the former Hanley Area may be contributing to indoor air quality which could potentially affect the adjacent Job Corps facility.
3. One tunnel air and one outdoor air sample will be collected (if feasible) in the small utility tunnel located on the west side of former Building 220. The utility tunnel is suspected to connect former Building 220 with the building described as the “Transformer Station (244)” in Figures 2 and 14. The samples will be collected to assess whether contamination from the former Hanley Area may be contributing to indoor air quality which could potentially affect the adjacent Job Corps facility. The Army will request permission from the Job Corps to access the utility tunnel from Job Corps property.
4. During the sampling event, the tunnel floor and walls near the tunnel air sampling locations will be inspected for signs of cracks or other potential vapor entry points, such as air vents and utilities that penetrate the walls, floor, or ceiling. Floor drains (if present) will also be visually inspected for outward signs of damage. A chemical inventory will be completed during the sampling event (if chemicals are observed in the tunnel system or in the Transformer Station). Barometric pressure and weather conditions will be documented during the sampling event.
5. Additional investigations in the tunnel system and/or at the Job Corps facility will be considered, with stakeholder input, if it is determined that site-related VOCs are significant and occurring.

Optimization:

The data obtained will be used to in stakeholder decision-making on any path forward direction for the project, except for pre-agreed triggers to develop a path of no further action based on site data; see decision rules Step 5.

Worksheet #12—Measurement Performance Criteria

Measurement performance criteria (MPC) were established for groundwater, indoor air, outdoor air, and subslab soil gas analytical parameters of the project. Refer to the following worksheets for the required information in Worksheet #12:

- Worksheet #15 (*Reference Limits and Evaluation*) for data quality indicators consisting of precision and accuracy
- Worksheet #24 (*Analytical Instrument Calibration*) and Worksheet #28 (*Analytical Quality Control and Corrective Action*) for the requirements of laboratory QA/QC activities for groundwater and soil vapor analytical methods
- Worksheet # 35 (*Data Verification Procedures*) and Worksheet #36 (*Data Validation Procedures*) for data review and validation process
- Worksheet #37 (*Data Usability Assessment*) for PARCCS parameters

The quality of the data to be collected for this project will be verified using appropriate MPCs established for both sampling procedures and analytical methods. The criteria will relate to the data quality indicators. The MPCs follow those defined in the DoD QSM Version 4.2 (DoD 2010). The sampling procedures and the quality of the laboratory results will be evaluated for compliance with the project-specific DQOs through a review of overall PARCCS, in accordance with procedures described in Worksheet #37 (*Data Usability Assessment*). The results will be summarized in a data quality report, which will be included as an appendix to the RI report.

Worksheet #13—Secondary Data Uses and Limitations

Secondary data refer to historical data previously collected from the site. The source(s) of the data, date of collection, planned uses, and limitations of the secondary data are summarized in the Table 13-1.

TABLE 13-1
Secondary Data Criteria and Limitations
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Secondary Data	Source[a]	Date of Collection[b]	How Data Will Be Used	Limitations on Data Use[c]
Groundwater Data	USACE. 2005. *Technical Memorandum—Final Hanley Area Phase I Remedial Investigation, Former St. Louis Ordnance Plant, St. Louis. Missouri*. May.	February 2005	Data will be used for VI risk evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Groundwater Data	USACE. 2007. *Final Supplemental Soil and Groundwater Phase II Remedial Investigation Technical Memorandum, Hanley Area, Former St. Louis Ordnance Plant, St. Louis, Missouri*. June 25.	February 2006 and April 2007	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Indoor Air and Outdoor Air	CH2M HILL. 2009. *Final Remedial Investigation, St. Louis Ordnance Plant, Former Hanley, St. Louis, Missouri*. November.	March and May 2008	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Groundwater	CH2M HILL. 2009. *Final Remedial Investigation, St. Louis Ordnance Plant, Former Hanley, St. Louis, Missouri*. November.	June 2008	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Groundwater	CH2M HILL. 2011e. *Final Remedial Design/Remedial Action Work Plan, St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri*. September.	August 2010	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.

TABLE 13-1
Secondary Data Criteria and Limitations
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Secondary Data	Source[a]	Date of Collection[b]	How Data Will Be Used	Limitations on Data Use[c]
Subslab Soil Gas, Indoor Air, Outdoor Air, and Groundwater	CH2M HILL. 2011c. *Vapor Intrusion Assessment at Private Property PP-1, St. Louis, Missouri.* May. CH2M HILL. 2011d. *Vapor Intrusion Assessment at Private Property PP-17, St. Louis, Missouri*. May.	May 2011	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Subslab Soil Gas, Indoor Air, Outdoor Air, and Groundwater	CH2M HILL. 2012d. *December 2011 Vapor Intrusion Assessment at Private Property PP-1, St. Louis, Missouri.* April 20. CH2M HILL. 2012e. *December 2011 Vapor Intrusion Assessment at Private Property 17, St. Louis, Missouri.* April 20. CH2M HILL. 2011e. *Final Remedial Design/Remedial Action Work Plan, St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri*. September.	December 2011	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Subslab Soil Gas, Indoor Air, Outdoor Air, and Groundwater	CH2M HILL. 2012f. *February 2012 Vapor Intrusion Assessment at Private Property PP-2, St. Louis, Missouri.* May 10. CH2M HILL. 2012g. *February 2012 Vapor Intrusion Assessment at Private Property 3, St. Louis, Missouri.* May 10.	February 2012	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Subslab Soil Gas, Indoor Air, Outdoor Air, and Groundwater	CH2M HILL. 2012h. *June 2012 Vapor Intrusion Assessment at Private Property PP-1, St. Louis, Missouri.* September 28.	June 2012	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.
Groundwater	CH2M HILL. 2012i. *July 2012 Groundwater Monitoring Report—Operable Unit 1, St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri.* September.	July 2012	Data will be used for risk assessment evaluations.	Only validated analytical data of known quality will be used for project purposes. Any result that was qualified as unusable will not be carried forward for this project.

TABLE 13-1
Secondary Data Criteria and Limitations
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Secondary Data	Source[a]	Date of Collection[b]	How Data Will Be Used	Limitations on Data Use[c]
Boring Log Information	Previous site reports	Any year	Data will be used to generate geologic cross sections and to support the development of the conceptual site model.	None
Well Construction and Water Level Elevation Information	Previous site reports	Any year	Data will be used to support the development of the conceptual site model, potentiometric surface maps, and for future groundwater sample planning.	None
Geographic Information Systems Mapping Layers and Coordinates	Previous site reports	Any year	Data will be used to determine well, boring, sample, and site feature locations to support conceptual site models and nature and extent evaluations.	Review of data and professional judgment will be required to determine applicability and usability of data.
Photographs, Aerial Photography, Interviews with Site Personnel and Residents, or Other Sources of Data	Previous site reports; published literature	Any year	Data will be used to support conceptual site model development.	Review of data and professional judgment will be required to determine applicability and usability of data.

[a] Final documentation defined is associated with approved project-specific QAPPs.
[b] The earliest year of analytical data collection that will be used is 2005, and there are no significant changes from that timeline to current requirements for data collection. No limitation of data use is expected due to timeline-related issues for historical data.
[c] Historical analytical data may not reflect current site conditions. As stated in the conceptual site model presented in Worksheet #10, as well as DQO tables presented in Worksheet #11, the clay overburden encountered at the former Hanley Area and offsite to the north has prevented previous attempts to collect shallow soil gas samples. The clay soil has also hindered accurate water table measurements that may not represent the actual water table (Worksheet #10). The conditions have resulted in data gaps, which the project goals are designed to close. In addition, the breakdown of TCE over time leads to changing analytical concentrations in groundwater and/or soil gas as TCE degrades (reduced concentrations), and degradation products increase in concentrations.

Worksheet #14 and #16—Project Tasks and Schedule

Combined Worksheet #14 and #16 provides an overview of project tasks as the outcome of project scoping activities and includes a project schedule (Figure 15). The following project tasks are discussed:

- Pre-investigation activities
- Field investigation
- Laboratory analysis
- Data review, management, and usability
- Baseline HHRA
- Reporting

Field activities and procedures for the groundwater investigation to achieve DQO # 1, DQO #3, and DQO # 4 (if warranted, based on results of the groundwater investigation along Stratford Avenue) and the VI assessments to achieve DQO #2 are briefly summarized in the following sections and discussed further in the FSP (Appendix C). Discussions of quality assurance for the project are located in Worksheets #27, 29, 30, 31, 32, 33, 34, 35, 36, and 37. Figure 15 presents the project schedule.

Pre-Investigation Activities

Several activities will take place before the field activities begin. The activities will include conducting site reconnaissance, coordinating site access, obtaining clearances and required permits, and acquiring subcontractors and materials.

Groundwater Pre-investigation Activities

Using a global positioning system (GPS) unit to locate proposed colocated shallow and deep overburden monitoring well pair locations.

Securing subcontracts with a drilling contractor, the offsite analytical laboratory, waste disposal contractor, and surveyor. This task also includes scheduling public and third-party private utility clearances and procurement of sampling equipment and supplies.

The Army will obtain a permit from the City of St. Louis to install permanent monitoring wells along Stratford Avenue (and on Henner Avenue, based on results of the groundwater investigation along Stratford Avenue).

The Army will obtain a ROE from the resident at PP-17 to install a permanent colocated well pair.

VI Assessment Pre-investigation Activities

Subcontracts securing the offsite analytical laboratory and waste disposal contractor will be completed. This task also includes scheduling public and third-party private utility clearances and procurement of sampling equipment and supplies.

After the Army obtains signed rights of entries for the residences, CH2M HILL will conduct an initial site visit at PP-2 through PP-5 and PP-17 to collect information for the VI assessments. During the site visit, CH2M HILL will interview the residents and perform a limited building inspection to obtain the following information:

- Occupancy status (number of people living at the residence, duration at the current residence, age of occupants, etc.)
- General building layout, including number of floors and approximate floor space area
- Building construction characteristics, including foundation type, basement or crawlspace details, and heating and ventilation system information
- Types of chemical products used and stored inside the residence that may contain VOCs

- Still photographic documentation of basement conditions

During the initial site visit, CH2M HILL will notify residents of the proposed locations of the groundwater (PP-17 only), subslab soil gas, indoor air, and outdoor air samples and obtain verbal approval from residents regarding the locations.

Field Investigation

Remedial Investigation of Groundwater along Stratford Avenue, at Plume C, and at the Day Care Center

Convert the onsite and offsite soil borings to colocated well pairs to achieve the PQOs and DQOs presented in Worksheet #11. Based on the results of the groundwater investigation along Stratford Avenue, three colocated well pairs may be installed near the day care center. The colocated well pairs will consist of a deep well that will terminate at the overburden and weathered shale bedrock contact and a colocated shallow well that will facilitate collection of groundwater at its first occurrence.

Two rounds of groundwater sampling, separated by at least 6 months, will be conducted at the nine colocated well pairs (excludes the colocated well pairs to achieve DQO # 4—day care center investigation) and at one deep monitoring well location (associated with characterizing the eastern extent of Plume C—DQO #3). One round of groundwater samples will also be collected at the existing monitoring wells to obtain a snapshot of current groundwater conditions during the RI to achieve DQO #1, DQO #3, and DQO #5 (excludes the colocated well pairs to achieve DQO #4). Groundwater samples will be collected for select VOCs using low-flow techniques during each event. During the groundwater sampling events, water quality parameters will be analyzed using field methods for dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, and pH.

Decontamination fluids and purge water generated during well development and groundwater sampling will be placed in 55-gallon drums, characterized, and disposed of in the City of St. Louis combined stormwater and sanitary sewer collection system upon approval from the St. Louis Metropolitan Sewer District. Soil cuttings generated during monitoring well installation activities will be characterized and disposed offsite as nonhazardous waste (anticipated classification based on previous investigations). Trash and personal protective equipment will be disposed of in a dumpster at the former Hanley Area.

Groundwater elevation data from the existing monitoring wells and the colocated well pairs will be used to evaluate groundwater flow direction.

The location and elevation of each newly-installed colocated well pair will be surveyed by a licensed surveyor.

VI Assessments at PP-2 through PP-5 and at PP-17

At PP-4 and PP-5, install subslab soil gas probes through the floor of the basement at up to two locations approved by the resident during the initial site visit. Subslab soil gas probes were installed at PP-2, PP-3, and PP-17 during previous VI assessments. The subslab soil gas sampling probes will remain in the slab for possible subsequent sampling events. Based on the results of the groundwater investigation along Stratford Avenue, a VI assessment may be conducted at the day care center.

Following successful helium leak checks of the subslab soil gas sample locations during purging activities, deploy sample canisters for subslab soil gas, indoor air, and outdoor air sampling.

Individually certified 6-liter SUMMA canisters will be used to collect the subslab soil gas samples, indoor air samples, and outdoor air samples. The canisters will be kept open for 24 hours using a flow controller set for 3.75 milliliters per minute, which will allow the SUMMA canister to fill over a 24-hour period.

Up to three VI assessments, with each event separated by at least 3 months, will be conducted at PP-2 through PP-5 and at PP-17 (and the day care center, if warranted). Subslab soil gas, indoor air, and outdoor air samples will be collected for select VOCs using the low-level selective ion mode (SIM) laboratory analysis method. During each VI assessment, weather conditions, condition of the floor and walls (if different than what was

observed during the initial site visit), and types of chemicals present in the basement (if different than what was observed during the initial site visit) will be documented.

Up to three rounds of groundwater sampling (includes the two rounds to achieve DQO #1 and DQO #3), separated by at least 3 months, will be conducted at the colocated monitoring well pairs adjacent to PP-2 through PP-5 and PP-17 (and at the colocated well pairs near the day care center, if warranted). Monitoring well MW-116 will also be sampled to assess groundwater conditions near PP-2. Groundwater samples will be collected for select VOCs using low-flow techniques during each event. During the groundwater sampling events, water quality parameters will be analyzed using field methods for dissolved oxygen, oxidation-reduction potential, temperature, specific conductance, and pH.

Decontamination fluids and purge water generated during groundwater sampling will be placed in 55-gallon drums, characterized, and disposed of in the City of St. Louis combined stormwater and sanitary sewer collection system upon approval from the St. Louis Metropolitan Sewer District. Trash and personal protective equipment will be disposed of in a dumpster at the former Hanley Area.

Groundwater elevation data from the existing monitoring wells and the colocated well pairs will be used to evaluate groundwater flow direction.

Tunnel Air Sampling

In and above the main tunnel system and the small utility tunnel depicted in Figure 14, deploy sample canisters for indoor air and outdoor air sampling to achieve DQO #6. Deployment of sample canisters on Job Corps property is contingent on the Army receiving permission from the Job Corps to do so.

Individually certified 6-liter SUMMA canisters will be used to collect the indoor air samples and outdoor air samples. The canisters will be kept open for 24 hours using a flow controller set for 3.75 milliliters per minute, which will allow the SUMMA canister to fill over a 24-hour period.

Two rounds of tunnel air sampling, with each event separated by at least 3 months, will be conducted in the main tunnel system. One round of tunnel air sampling will be conducted in the small utility tunnel located on the west side of former Building 220 (if feasible). Indoor air and outdoor air samples will be collected for select VOCs using the low-level SIM laboratory analysis method. During each sampling event, the following will be documented: weather conditions, condition of the floor and walls (if different than what was observed during the initial site visit), and types of chemicals present in the tunnel system and the Job Corps building identified as the “Transformer Station” on site figures.

Trash and personal protective equipment will be disposed of in a dumpster at the former Hanley Area.

Laboratory Analysis

Laboratory analyses are described in Worksheet #17 (Sampling Design and Rationale) and summarized in the following paragraphs.

Samples will be analyzed for select VOCs as defined in Worksheet #15. Groundwater samples will be analyzed by Method SW8260B and subslab soil gas, indoor air, and outdoor air samples will be analyzed by Method TO-15 SIM.

Empirical Laboratory in Nashville, Tennessee, will analyze the groundwater samples. Applied Sciences Laboratory in Corvallis, Oregon, will analyze the subslab soil gas, indoor air, and outdoor air samples. There will be no QA split samples collected for this project effort. ASL and Empirical Laboratory hold current DoD Environmental Laboratory Accreditation Program (ELAP) certification for the required methods. The laboratory analyses will be performed in accordance with the analytical methods, this UFP-QAPP, and the LSOPs as defined in Worksheet #23 (Analytical SOPs).

Data Management, Review and Usability

Data Management

Hard copy and electronic data (field and laboratory) will be tracked, stored, handled, and managed. Field activities will be recorded in project logbooks and on the applicable standard field forms provided in the FSP (Appendix C). Site maps will be maintained and sample locations will be updated on the maps as necessary. Field and analytical data will be consolidated and maintained within an electronic database management system. The database management system will be used to perform sample tracking, storage of electronic data, validation of data, querying data for analysis, and preparation of final data tables.

Documents and Records

Project-related data, including field logs, field forms, chain-of-custody forms, correspondence, and project reports will be maintained in hard copy and/or electronic format (PDF) at the CH2M HILL St. Louis office.

Data Review

A three-step data review process (consisting of verification, validation, and usability assessment) will be employed to examine the collected data so that only scientifically-sound data of known and documented quality are used to make environmental decisions. Worksheets #34 (Data Verification and Validation Input) through #37 (Data Usability Assessment) describes the process and criteria in detail.

Analytical data obtained during the project will be validated by a qualified CH2M HILL chemist according to the specifications provided in Worksheet #36 (Data Validation Procedures). Full documentation of the data validation process and the results will be provided in an appendix to the RI report.

Data Usability

The data usability assessment is an evaluation based on the results of data validation in the context of the overall project decisions and objectives. The assessment is used to determine whether the project execution and resulting data meet the project DQOs (Worksheet #11). Both the sampling and analytical activities must be considered, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data. Worksheet #37 (Data Usability Assessment) describes the process in detail.

As part of the data usability assessment, field data will be compiled from field logs and presented in the RI report listing the sampling details, field observations, and field parameter measurements. Field data will be used to further refine the understanding of site conditions and to update the conceptual site model, as appropriate.

Before data presentation and evaluation, analytical data will be processed to identify the “best result” for a given sample based on unique location, time, medium, and depth. The best result will then be used to compare to the applicable project action levels, to evaluate the nature and extent of contamination, and to prepare the HHRA. Best result processing is needed to produce a single representative value for each sample because of multiple records that may result from field duplicates (FDs).

A protocol has been developed that will be used to identify the best result for each sample in the project database, using the following general logic:

- If all results for a given sample are qualified as detected, then the maximum detected result is selected as best result.
- If some results for a given sample are qualified as detected and some qualified as nondetected, then the maximum detected result is selected as best result.
- If all results for a given sample are qualified as nondetected, then the result with the lowest quantitation limit is selected as the best result.
- If not rejected, flagged data will be used in the same way as the non-flagged data.

The results of the best result processing will be included in an appendix to the RI report.

Human Health Risk Assessment

As part of the RI, an HHRA will evaluate potential risks associated with onsite tunnel air under the "no action" alternative (including no controls to maintain the integrity of the existing barriers blocking tunnel access). Tunnel air data will be compared to USEPA's Regional Screening Levels (RSLs) for industrial air to identify chemicals of potential concern (COPCs; chemicals that exceeded the regulatory targets). If COPCs are identified, a reasonable maximum exposure scenario will be quantified for a hypothetical future adult trespasser (for example, a student from the Job Corps facility) who accesses the tunnel for 1 to 2 days per month (20 days per year) over a 5-year period. It should be noted that aboveground access to the main tunnel system is currently blocked with heavy steel barriers that require the use of heavy machinery to remove. The existing tunnel barriers at each Job Corps property boundary crossing will be assessed during field reconnaissance, assuming that the locations can be safely accessed. Assuming that the tunnel process is currently blocked at each property boundary crossing, future trespasser exposure to tunnel air will be considered highly unlikely. However, the exposure scenario will be evaluated in the HHRA as a conservative measure.

Also as part of the RI, an HHRA will be conducted for the residential VI pathway. The HHRA will use subslab soil gas and indoor air results from the 2008 RI, previous VI assessments at PP-2, PP-3, and PP-17, and data collected during the OU-2 RI. The risk assessment will evaluate potential current and future human health risks to residents in the neighborhood north of the former Hanley Area. The HHRA will also provide information to support the development, evaluation, and selection of appropriate response alternatives, if needed. The HHRA will be conducted in accordance with *Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual*, Parts A, E, and F (USEPA 1989, 2004, and 2009). Risk calculations will be performed for PP-2 through PP-5 and PP-17, as described in the following paragraphs.

To evaluate potential current risk at each residence, site-related COPCs were identified in groundwater during the 2008 RI (CH2M HILL 2009). The COPCs identified during the 2008 RI will be used as preliminary COPCs for the OU-2 RI. The preliminary COPCs that exceed the screening levels presented in Worksheet #15 and are likely caused by VI based on the lines of evidence presented in the technical memorandums will be identified as COPCs. In the HHRA, the maximum concentration of each chemical obtained from multiple rounds of VI assessments (for example, subslab soil gas and indoor air) will be used.

If one or more indoor air concentration exceeds screening levels at the residence due to VI, then the current inhalation risk will be estimated using the measured indoor air concentrations of the site-related COPCs. The cumulative ELCR and noncancer hazard indices (or target-organ-specific hazard indices, if necessary) will be calculated for site-related preliminary COPCs for adult and child residents. Individual and cumulative ELCRs and hazard indices will be compared to USEPA and state acceptable risk thresholds identified in Worksheet #15. Chemicals exceeding thresholds will be identified as preliminary COCs.

To evaluate potential future residential risk at each residence, subslab gas concentrations will be evaluated to identify potential future COPCs in indoor air. Subslab gas concentrations will be compared to the screening levels identified in Worksheet #15, along with additional lines of evidence (refer to Worksheet #11), to identify future COPCs for the indoor air pathway. After future exposure point concentrations are identified for COPCs, risk estimates will be calculated and preliminary COCs identified following the procedure described above for current risk estimates.

Uncertainties in the risk assessment process also will be presented to better characterize the numerical risk results. The HHRA will be prepared as a section of the RI report.

Preliminary COCs will be addressed in the FS phase during the development of remedial action objectives.

Reporting

VI Assessment Technical Memorandum

Following the completion of each VI assessment, a technical memorandum will be prepared for each residence where a VI assessment was performed. Each technical memorandum will be similar in format and content to

CH2M HILL's *June 2012 Vapor Intrusion Assessment at Private Property 1, St. Louis, Missouri* (2012h). Each technical memorandum will describe the objectives, methods, findings, and conclusions of the VI assessment. It will compare chemical concentrations in subslab soil gas and indoor air against the screening levels presented in Worksheet #15.

Subslab soil gas, indoor air, and outdoor air sample locations will be depicted on a figure and may be based on taped distances from the outer building walls, because obtaining GPS coordinates within/near the structure may not be possible. The technical memorandum will include daily QC reports, laboratory analytical results, and the data quality evaluation report as attachments.

The technical memorandum will discuss chemical concentrations exceeding screening levels (if any) and identify possible sources of those chemicals based on the following lines of evidence:

- Comparison of chemicals detected in indoor air samples and subslab samples
- Comparison of chemicals detected in indoor air and ambient air samples
- Evaluation of chemical sources inside the home identified during the initial site visit

In addition to evaluating possible sources of VOCs measured above screening levels (if any), each technical memorandum will assess the potential for vapors in the subslab to migrate into the residence. The evaluation will be based on the following:

- Chemical concentrations measured in the subslab soil gas
- Concentration ratios between subslab soil gas, indoor air, and ambient air
- Observed condition of the building floor (for example, cracks, floor drains, etc.)

Each technical memorandum will assess whether the former Hanley Area is the primary source of contamination (if present) in the subslab soil gas and/or indoor air, which will be done by determining if there is a correlation between results from subslab soil gas, indoor/outdoor air, and onsite and offsite groundwater samples collected during and subsequent to the OU-2 groundwater investigation. If the results are inconclusive regarding whether the former Hanley Area is a contributing source, the technical memorandum will provide recommendations for further investigation.

If the results from the VI assessment indicate that site-related VOCs are entering buildings through VI, causing exceedances above regulatory targets, the stakeholders will be notified and mitigation measures will be discussed during the FS. Results of the technical memorandum will be included in the risk assessment to determine if site-related VOCs are contributing to VI.

Following resolution of comments on the draft VI technical memorandums, the final technical memorandums will be submitted to the Army, MDNR, and USEPA. The property owner and resident will also receive copies of the final technical memorandums.

RI Report

An RI report will be prepared in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988b). In addition to investigation data collected during the OU-2 RI, the RI report will employ data from the following previous investigations, as appropriate:

- VI assessments at PP-1 and PP-17 performed in 2011 and 2012
- VI assessments at PP-2 performed in 2008 and 2012
- VI assessment at PP-3 performed in 2012
- Groundwater samples collected from permanent monitoring wells between 2005 and 2012

The RI report will summarize the nature and extent of VOCs in groundwater, subslab soil gas, indoor air, tunnel air, and outdoor air from the investigations identified above. It will present a conceptual site model based on observed subsurface soil lithology, groundwater elevations, presence of utility corridors, and chemical concentrations. The RI report will evaluate the potential fate and transport of VOCs from the former Hanley Area to offsite properties, and it will assess the potential for chemical migration from groundwater to subslab soil gas and indoor air.

Worksheet #15—Reference Limits and Evaluation

One of the primary goals of the project-specific QAPP is to select appropriate analytical methods to achieve DLs, limit of detections (LOD), and/or limit of quantitations (LOQs) that will satisfy the overall project DQOs (as defined in Worksheets # 10 [Conceptual Site Model] and #11 [Project/Data Quality Objectives]).

To determine whether the DL, LOD, and LOQ will meet the analytical DQOs, the DLs, LODs, and LOQs have been compared to the project-specific screening criteria as follows:

Groundwater: In March 2012, USEPA released a VISL calculator that provides conservative default VISLs. To meet the objectives of the OU-2 RI, the VISLs (June 2013 update) for groundwater are based on residential use, an attenuation factor of 0.001 for groundwater-to-indoor air, an ELCR of 1×10^{-6}, and an HQ of 1.0 for noncarcinogens.

Indoor Air: The offsite VI assessments and tunnel air sampling will use target indoor air concentrations based on residential use provided in the VISL calculator, using the ELCR and HQ identified above. Outdoor air data will be used for comparison with indoor air concentrations to determine if the measured indoor air concentrations are associated with outdoor air infiltration.

Subslab Soil Gas: The target subslab and exterior soil gas concentrations based on residential use provided in the VISL calculator, using the ELCR and HQ identified above. The target subslab soil gas is the target indoor air concentration divided by the generic attenuation factor for soil gas (default value = 0.1).

Tables 15-1 through 15-3 show the primary screening criteria with respect to the current analytical DL, LOD, and LOQ for each listed target compound. There are three water compounds and two indoor air compounds where the LOD and/or LOQ exceed screening criteria; however, the DL is at or below the screening criteria and will be used to meet project objectives. Analytical methods with the lowest possible DLs have been selected in order to meet as many project-specific goals as reasonably possible.

If the LOD is below the screening criterion, the LOD and/or the LOQ are sufficient for quantitative use in the risk assessment. In situations where the LOD/LOQ are not below the screening level, a closer examination of the specific compounds will be required to determine if these compounds are site-specific and whether or not the data quality of the project has been impacted. The DL will be used if a target compound is detected at or above this concentration. The DL is typically two to three times lower than the LOD. The LOD or the DL will be used to evaluate project objectives in the event that the LOQ exceeds the screening criterion. In addition, chemical-specific factors (mobility and toxicity) may be discussed and included in the risk assessment on a more qualitative basis.

Note that sample dilution because of target and or non-target compound concentrations or matrix interference may prevent DLs, LODs, or LOQs from being achieved. The samples must be initially analyzed undiluted when reasonable. If a dilution is necessary, both the original and diluted result must be delivered. Samples that are not analyzed undiluted must be supported by matrix interference documentation such as sample viscosity, color, odor, or results from other analyses of the same sample to show that an undiluted sample is not possible.

TABLE 15-1

Reporting Limit Objectives for VOCs in Groundwater by Method SW8260B

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Method	Compound	CAS	Units	VISL	LOQ	Does LOQ Exceed Screening Level?	LOD	Does LOD Exceed Screening Level?	DL	Does DL Exceed Screening Level?	Surrogate	Percent Recovery		RPD
												Lower Limit	Upper Limit	
SW8260B	1,1,1,2-TeCA	630-20-6	µg/L	3.2	1	NO	0.5	NO	0.15	NO	NO	80	130	30
SW8260B	1,1,2,2-TeCA	79-34-5	µg/L	2.8	1	NO	0.5	NO	0.14	NO	NO	65	130	30
SW8260B	1,1,2-TCA	79-00-5	µg/L	4.5	1	NO	0.5	NO	0.20	NO	NO	75	125	30
SW8260B	1,2-DCA	107-06-2	µg/L	1.9	1	NO	0.5	NO	0.16	NO	NO	70	130	30
SW8260B	Benzene	71-43-2	µg/L	1.4	1	NO	0.5	NO	0.15	NO	NO	80	120	30
SW8260B	Carbon tetrachloride	56-23-5	µg/L	0.36	1	**YES**	0.5	**YES**	0.17	NO	NO	65	140	30
SW8260B	Chloroform	67-66-3	µg/L	0.71	1	**YES**	0.5	NO	0.17	NO	NO	65	135	30
SW8260B	*cis*-1,2-DCE	156-59-2	µg/L	380	1	NO	0.5	NO	0.14	NO	NO	70	125	30
SW8260B	Methylene chloride	75-09-2	µg/L	720	2	NO	1	NO	0.12	NO	NO	55	140	30
SW8260B	Naphthalene	91-20-3	µg/L	4	1	NO	0.5	NO	0.16	NO	NO	55	140	30
SW8260B	PCE	127-18-4	µg/L	13	1	NO	0.5	NO	0.23	NO	NO	45	150	30
SW8260B	*trans*-1,2-DCA	156-60-5	µg/L	380	1	NO	0.5	NO	0.22	NO	NO	60	140	30
SW8260B	TCE	79-01-6	µg/L	1.1	1	NO	0.5	NO	0.19	NO	NO	70	125	30
SW8260B	Vinyl chloride	75-01-4	µg/L	0.14	1	**YES**	0.5	**YES**	0.14	NO	NO	50	145	30
SW8260B	1,2-DCA-d4	17060-07-0	%	--	--			--	--	--	YES	70	120	--
SW8260B	Bromofluorobenzene	460-00-4	%	--	--			--	--	--	YES	75	120	--
SW8260B	Dibromofluoromethane	1868-53-7	%	--	--			--	--	--	YES	85	115	--
SW8260B	Toluene-d8	2037-26-5	%	--	--			--	--	--	YES	85	120	--

Notes:

RPD = relative percent difference

Compounds with "%" units are surrogates and are not a part of the target analytes

DoD QSM QC limits used for percent recovery

VISLs are based on an attenuation factor of 0.001 for groundwater-to-indoor air, an ELCR of 1×10^{-6}, and a hazard quotient of 1.0 for noncarcinogens.

Bolded "**YES**" results indicate LOQ and/or LOD values that exceed the selected screening levels.

TABLE 15-2
Reporting Limit Objectives for VOCs in Indoor Air by Method TO-15 SIM
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Method	Compound	CAS	Units	VISL	LOQ	Does LOQ Exceed Screening Level?	LOD	Does LOD Exceed Screening Level?	DL	Does DL Exceed Screening Level?	Surrogate	Percent Recovery		RPD
												Lower Limit	Upper Limit	
TO15-SIM	1,1,2,2-TeCA	79-34-5	µg/m³	0.042	0.07	**YES**	0.035	NO	0.014	NO	NO	70	130	30
TO15-SIM	1,1,2-TCA	79-00-5	µg/m³	0.15	0.055	NO	0.028	NO	0.011	NO	NO	86	117	30
TO15-SIM	1,2-DCA	107-06-2	µg/m³	0.094	0.041	NO	0.021	NO	0.008	NO	NO	87	117	30
TO15-SIM	Benzene	71-43-2	µg/m³	0.31	0.032	NO	0.016	NO	0.006	NO	NO	75	109	30
TO15-SIM	Carbon tetrachloride	56-23-5	µg/m³	0.41	0.064	NO	0.032	NO	0.013	NO	NO	84	118	30
TO15-SIM	Chloroform	67-66-3	µg/m³	0.11	0.05	NO	0.025	NO	0.010	NO	NO	84	120	30
TO15-SIM	*cis*-1,2-DCE	156-59-2	µg/m³	63	0.04	NO	0.02	NO	0.016	NO	NO	82	120	30
TO15-SIM	Methylene chloride	75-09-2	µg/m³	96	0.035	NO	0.018	NO	0.014	NO	NO	71	109	30
TO15-SIM	Naphthalene	91-20-3	µg/m³	0.072	0.16	**YES**	0.16	**YES**	0.053	NO	NO	38	149	30
TO15-SIM	PCE	127-18-4	µg/m³	9.4	0.069	NO	0.034	NO	0.014	NO	NO	83	122	30
TO15-SIM	*trans*-1,2-DCA	156-60-5	µg/m³	63	0.04	NO	0.02	NO	0.008	NO	NO	85	118	30
TO15-SIM	TCE	79-01-6	µg/m³	0.43	0.055	NO	0.027	NO	0.011	NO	NO	83	117	30
TO15-SIM	Vinyl chloride	75-01-4	µg/m³	0.16	0.026	NO	0.013	NO	0.01	NO	NO	74	125	30
TO15-SIM	Bromofluorobenzene	460-00-4	%	--			--	--	--	--	YES	92	117	--
TO15-SIM	Toluene-d8	2037-26-5	%	--			--	--	--	--	YES	95	106	--

Notes:
Compounds with "%" units are surrogates and are not a part of the target analytes
Laboratory statistical QC limits were used for percent recovery
VISLs are based on May 2013 USEPA RSLs for Residential air
Bolded "**YES**" results indicate LOQ and/or LOD values that exceed the selected screening levels.

TABLE 15-3

Reporting Limit Objectives for VOCs in Subslab Soil Gas by Method TO-15 SIM

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Method	Compound	CAS	Units	VISL	LOQ	Does LOQ Exceed Screening Level?	LOD	Does LOD Exceed Screening Level?	DL	Does DL Exceed Screening Level?	Surrogate	Percent Recovery		RPD
												Lower Limit	Upper Limit	
TO15-SIM	1,1,2,2-TeCA	79-34-5	µg/m³	0.42	0.07	NO	0.035	NO	0.014	NO	NO	70	130	30
TO15-SIM	1,1,2-TCA	79-00-5	µg/m³	1.5	0.055	NO	0.028	NO	0.011	NO	NO	86	117	30
TO15-SIM	1,2-DCA	107-06-2	µg/m³	0.94	0.041	NO	0.021	NO	0.008	NO	NO	87	117	30
TO15-SIM	Benzene	71-43-2	µg/m³	3.1	0.032	NO	0.016	NO	0.006	NO	NO	75	109	30
TO15-SIM	Carbon tetrachloride	56-23-5	µg/m³	4.1	0.064	NO	0.032	NO	0.013	NO	NO	84	118	30
TO15-SIM	Chloroform	67-66-3	µg/m³	1.1	0.05	NO	0.025	NO	0.010	NO	NO	84	120	30
TO15-SIM	*cis*-1,2-DCE	156-59-2	µg/m³	630	0.04	NO	0.02	NO	0.016	NO	NO	82	120	30
TO15-SIM	Methylene chloride	75-09-2	µg/m³	960	0.035	NO	0.018	NO	0.014	NO	NO	71	109	30
TO15-SIM	Naphthalene	91-20-3	µg/m³	0.72	0.16	NO	0.16	NO	0.053	NO	NO	38	149	30
TO15-SIM	PCE	127-18-4	µg/m³	94	0.069	NO	0.034	NO	0.014	NO	NO	83	122	30
TO15-SIM	*trans*-1,2-DCA	156-60-5	µg/m³	630	0.04	NO	0.02	NO	0.008	NO	NO	85	118	30
TO15-SIM	TCE	79-01-6	µg/m³	4.3	0.055	NO	0.027	NO	0.011	NO	NO	83	117	30
TO15-SIM	Vinyl chloride	75-01-4	µg/m³	1.6	0.026	NO	0.013	NO	0.01	NO	NO	74	125	30
TO15-SIM	Bromofluorobenzene	460-00-4	%	--	--			--	--	--	YES	92	117	--
TO15-SIM	Toluene-d8	2037-26-5	%	--	--			--	--	--	YES	95	106	--

Notes:

Compounds with "%" units are surrogates and are not a part of the target analytes

Laboratory statistical QC limits were used for percent recovery

VISLs were based on May 2013 USEPA RSLs for residential air adjusted for the subslab soil-gas-to-indoor air attenuation factor of 0.1

Worksheet #17—Sampling Design and Rationale

Worksheet #17 describes the field investigation activities planned. The field activities will be conducted in accordance with the FSP (Appendix C). The number of samples and the analytical parameters planned are summarized in Worksheet #18, Sampling Locations and Methods.

Because of the dynamic nature of the project, investigation locations and quantities indicated herein may be modified during the actual fieldwork and based on stakeholder input.

Colocated Monitoring Well Installation

Colocated shallow and deep overburden well pairs will be installed at locations shown in Figure 10. The intent of the shallow and deep colocated monitoring wells is to evaluate concentrations of site-related VOCs at the water table (where VOCs are most likely to volatilize) compared to VOC concentrations across several feet of the saturated zone.

From a VI perspective, groundwater VOC concentrations at the water table are of interest because they indicate potential volatilization of chemicals from groundwater to soil gas. Based on the lithology observed in the subsurface (tight clays with discontinuous lenses of coarser grained, more permeable materials) and the low groundwater recharge rate observed in the overburden soils, the depth to groundwater onsite and north of the former Hanley Area is uncertain. It is currently not known if groundwater in the wells that extend to the top of the overburden/weathered shale contact are representative of groundwater conditions at the water table because the screened intervals of the existing monitoring wells are fully submerged. For this reason, colocated shallow and deep overburden monitoring wells will be installed during the initial phase of the RI to increase the likelihood that one of the colocated wells would intercept the water table.

Colocated shallow and deep overburden monitoring well pairs (installed in separate boreholes) will be installed to achieve the DQOs presented in Worksheet #11, Project/Data Quality Objectives:

- DQO #1—Groundwater Investigation Along Stratford Avenue and at PP-17 to Determine if Further Investigation is Warranted
- DQO #3—Groundwater Investigation West and East of Monitoring Well MW-118 to Confirm or Refine the Plume C LUC Boundary and to Determine if Shallow Groundwater Could Contribute to VI at the Job Corps Facility
- DQO #4—Groundwater Investigation Near Day Care Center to Determine if a VI Assessment is Warranted
- DQO #5—Refine Groundwater Flow Direction and Assess Groundwater Conditions Northwest of the Former Hanley Area

Figure 10 presents the locations of the proposed colocated well pairs, and Figure 16 presents construction details for the colocated well pairs.

DQO #1—Groundwater Investigation along Stratford Avenue and at PP-17

During the September 19, 2012, OU-2 strategy meeting (refer to Worksheet #9), it was agreed among the Army (88th RSC, USAEC, and USACE), MDNR, USEPA, and CH2M HILL that a phased or “follow the evidence” approach would be implemented during the RI to achieve the investigation objectives (refer to the Executive Summary for investigation objectives). During the first phase of the RI, six colocated overburden monitoring well pairs will be installed along Stratford Avenue to assess groundwater conditions at the water table and near PP-1 through PP-8 (Figure 10). Existing monitoring wells MW-107, MW-108, and MW-109 terminate at the overburden/weathered shale contact and their well screens are fully submerged. Therefore, shallow wells will be installed next to each of these existing wells to assess groundwater conditions at the water table.

Borehole drilling and soil sample collection (for logging purposes only) will be performed in accordance with the latest ASTM methods D-1452 (Soil Investigation and Sampling by Auger Borings), D-1586 (Penetration Test and Split-barrel Sampling of Soils), and D-1587, where appropriate.

Soil from the three deep soil borings will be logged continuously from the ground surface to the termination depth, in accordance with the SOP, *Soil Boring Logging*, contained in the FSP. Soil boring logs for monitoring wells MW-107 through MW-109 are available. Soil logging of the shallow soil borings is not necessary because they will be located within 18 inches of the deep soil borings. Continuous 5-foot core barrel (or equivalent) samples will be advanced using 4.25-inch-inside-diameter hollow-stem augers at each soil boring location.

Each colocated shallow and deep monitoring well pair will be installed in accordance with the Missouri Well Construction Rules (10 *Code of State Regulation*s 23-1.010 through 6.060). Each monitoring well will be installed using a hollow-stem auger rig and will consist of 2-inch-inside-diameter Schedule 40 polyvinyl chloride pipe with a 10-foot screened interval. The screened interval will consist of 0.01-inch-wide slots. The deeper well will terminate at the overburden/weathered shale contact, and the shallow well will be screened at a higher depth interval (for example, the shallow well screens will straddle the water table) to facilitate collection of groundwater at its first occurrence. Construction details for the colocated well pairs are provided in Figure 10. Existing monitoring wells MW-107, MW-108, and MW-109 terminate at the overburden/weathered shale contact and their well screens are fully submerged. Therefore, shallow wells will be installed next to each of these existing wells to assess groundwater conditions at the water table. At the time of well installation, the field geologist will prepare a well installation diagram illustrating the depth of each boring, screen location, sand filter pack material, seal thickness, and other well construction information.

The drilling equipment will be decontaminated between holes using high-pressure steam cleaning equipment. After construction and installation activities, each well will be developed to restore the natural hydraulic characteristics of the aquifer near the monitoring well. The well development will be accomplished no sooner than 24 hours after well installation. General SOPs for monitoring well installation, well development, and decontamination procedures are presented in the FSP.

Soil cuttings, decontamination water, and purge water generated during development activities will be collected and stored in 55-gallon drums as investigation-derived waste (IDW) and are further discussed in the FSP.

Reference the Decision Logic flow diagram (Figure 10) for DQO #1 (Worksheet #11) for decisions concerning installation of colocated well pairs.

DQO #3—Groundwater Investigation West and East of MW-118

Low-flow and passive diffusion bag groundwater sample results at MW-118 indicate that concentrations of CT above the remediation goal of 3,200 µg/L and concentrations of TCE above the risk-based threshold of 2,320 µg/L during the July and November 2012 OU-1 LTM sampling events. Chloroform also was detected below the risk-based threshold, but at a concentration roughly 4.5 to 5 times higher than what was observed in August 2010. Because of the slow recharge of groundwater into the monitoring well, groundwater may not have reached equilibrium between the time MW-118 was installed and subsequent sampling in August 2010. The well was developed on August 12, 2010, and sampled the following day.

CT concentrations in upgradient (MW-115) and downgradient (MW-113, MW-114) monitoring wells were monitored to evaluate whether the Plume C LUC boundaries adequately cover the area where CT concentrations exceed the remediation goal and where TCE exceeded the risk-based threshold. Concentrations of CT, TCE, and degradation products were not detected at concentrations exceeding the remediation goals or risk-based thresholds presented in the LTM/LUCIP for OU-1. The LUC boundaries adequately cover the areas to the north and south of Plume C.

During the September 19, 2012, OU-2 strategy meeting (refer to Worksheet #9), it was agreed that one colocated shallow and deep overburden monitoring well pair would be installed to confirm that the current LUC boundaries at Plume C are protective or to refine the LUC boundaries (Figure 10) and to assess shallow groundwater conditions to assess the VI pathway near the Job Corps facility.

Because of the elevated CT and TCE concentrations at MW-118, the uncertainty associated with the VI pathway near the Job Corps facility, and to confirm that the current LUC boundaries at Plume C (under OU-1) are protective of the groundwater direct-contact pathway for construction workers or to refine the LUC boundary west of MW-118, one colocated monitoring well pair will be installed west of MW-118 (Figure 10). To confirm that the current LUC boundaries at Plume C (under OU-1) are protective of the groundwater direct-contact pathway for construction workers or to refine the LUC boundary east of MW-118, one deep monitoring well will be installed east of MW-118 (Figure 10). Procedures for installing the colocated monitoring well pair and deep monitoring well will follow the same procedures summarized in the DQO #1 section above.

DQO #4—Groundwater Investigation near Day Care Center

During the September 19, 2012, OU-2 strategy meeting, MDHSS discussed the need to collect samples from the day care center located approximately 350 feet (1 block) northeast of the former Hanley Area. The Army acknowledged the preference of MDNR, MDHSS, and USEPA to collect samples near the day care center to assess whether contamination from the former Hanley Area may be impacting the center. The Army agreed to discuss possible VI investigation measures at the day care center.

On September 26, 2012, in response to discussions at the September 19, 2012, strategy meeting, the Army developed an investigation approach for the day care center. Representatives from 88th RSC, USAEC, USACE, and CH2M HILL participated in the teleconference meeting. The investigation approach was subsequently discussed among technical experts and senior management within USACE and USAEC. All parties endorsed the investigation approach. The Army presented the approach in a technical document titled *Investigation Approach for Day Care Center at 4725 Goodfellow Boulevard, St. Louis, Missouri* (CH2M HILL 2012b). The Army submitted the technical document to MDNR and USEPA for review on October 22, 2012. After reviewing the day care center investigation approach technical paper, MDNR sent a letter to the USACE–Kansas City District on November 8, 2012, concurring with the investigation approach and requesting one additional monitoring well in the alley near PP-11. Based on the meetings, the technical document, and the letter, the Army will use the following approach to conduct the day care center investigation. To maintain the phased or "follow-the-evidence" approach discussed during the OU-2 strategy meeting, the Army will perform the investigation at the day care center under the following conditions:

- The Army will install and sample the colocated monitoring well pairs along Stratford Avenue as discussed during the September 19, 2012, OU-2 strategy meeting.
- If any VOCs exceed VISLs in the shallowest water-producing well pairs at MW-107, MW-108, or MW-109, an investigation at the day care center will be performed as follows:
  - Install a colocated well pair south of the day care center, along the easement of Henner Avenue.
  - Consider a second and third colocated well pair southwest and west of the day care center in the easement of an existing alleyway.

Figure 10 depicts the proposed colocated monitoring well pairs near the day care center (based on results of the groundwater investigation along Stratford Avenue).

Procedures for installing the colocated monitoring well pairs will follow the same procedures summarized in the DQO #1 section above.

DQO #5—Groundwater Investigation Northwest of the Former Hanley Area

During the September 19, 2012, OU-2 strategy meeting, MDNR recommended installing an additional colocated monitoring well pair further west of the originally-proposed monitoring wells along Stratford Avenue (Figure 10). The well pair would serve to refine groundwater flow direction and gradient northwest of the former Hanley Area. Additionally, the well pair would also provide insight on potential sources of VOCs unrelated to the former Hanley Area. The Army agreed to install the additional colocated well pair under the condition that the analytical results at this colocated well pair would not necessarily trigger the need for additional monitoring wells or VI assessments; that determination would be based on the results from the colocated pair and others further east (closer to the former Hanley Area).

Procedures for installing the colocated monitoring well pairs will follow the same procedures summarized in the DQO #1 section above.

Collection of Groundwater Samples

Sampling of the colocated monitoring well pairs to achieve DQOs # 1, #3, #4, and #5 will take place no sooner than 24 hours after well development has been completed and after water levels have reached equilibrium following well development. In addition, one round of groundwater samples will be collected from the existing monitoring well network to assess current groundwater conditions during the RI. Groundwater wells will be purged in accordance with the SOP, *Low-Flow Groundwater Sampling*, and sampling will be conducted in accordance with the SOP, *Water Sample Collection for Volatile Organic Compounds*, contained in the FSP. The Decision Logic diagram for DQO #1 (Worksheet #11) provides decisions concerning groundwater sampling.

Static depth to groundwater measurements will be recorded in accordance with the SOP, *Water Level Measurements*, at the existing and newly installed monitoring wells before each groundwater sampling event. Depth-to-groundwater measurements, temperature, pH, turbidity, dissolved oxygen, oxidation-reduction potential, and specific conductance measurements will be recorded before, during, and after purging each well.

Groundwater samples will be analyzed for the following VOCs that exceeded the historical drinking water USEPA Region 6 MSSLs during the OU-1 RI:

- Benzene
- CT
- Chloroform
- 1,2-DCA
- *cis*-1,2-DCE
- *trans*-1,2-DCE
- Methylene chloride
- Naphthalene
- 1,1,1,2-TeCA
- 1,1,2,2-TeCA
- 1,1,2-TCA
- PCE
- TCE
- Vinyl chloride

Methylene chloride (degradation product of CT) was added at MDNR's request during the FS.

Vapor Intrusion Assessment

VI assessments at PP-2 through PP-5 and at PP-17 will be conducted to achieve the DQO #2 presented in Worksheet #11, Project/Data Quality Objectives.

Field activities will be performed by a two-person team consisting of the field team leader/QC officer and a field team member experienced in subslab soil gas, indoor air, and ambient air sampling.

On the first day of the investigation at PP-2 through PP-5 and PP-17 (Figure 3), CH2M HILL will install subslab soil gas probes through the floor of the basement at up to two locations approved by the resident during the initial site visit. Subslab soil gas sample probes were previously installed at PP-2, PP-3, and PP-15. The probes will be installed in accordance with the SOP, *Collection of Subslab Gas Samples Using SUMMA Canisters*. Observations made during previous VI assessments at residences north of the former Hanley Area indicated basement floor thicknesses that would not allow for installation of the subslab soil gas sample probe at the appropriate depth. Therefore, an alternate method for sample probes installation is also provided in the FSP. The alternate installation method was previously provided in the *Vapor Intrusion Assessment Work Plan Addendum—Revision 1, Former Hanley Area, St. Louis Ordnance Plant, St. Louis, Missouri* (CH2M HILL 2011b). The subslab soil gas sampling probes will remain in the slab for possible subsequent sampling events.

On the second day, CH2M HILL will deploy sample canisters for subslab soil gas, indoor air, and ambient air sampling, in accordance with the SOP, *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*. For each subslab soil gas probe, CH2M HILL will conduct a helium-leak check before sampling, in accordance with the SOP.

Individually certified 6-liter SUMMA canisters will be used to collect the subslab soil gas samples, indoor air samples, and outdoor air samples. The canisters will be kept open for 24 hours using a flow controller set for 3.75 milliliters per minute, which will allow the SUMMA canister to fill over a 24-hour period.

For QC purposes, one FD sample will be collected of indoor air and subslab soil gas from each residence.

On the third day of the investigation at each residence, CH2M HILL will return to the residence and close the sample ports on the subslab soil gas, indoor air, and ambient air SUMMA canisters. CH2M HILL will arrive at the residence before 24 hours have elapsed since the canisters were opened to ensure the canisters have not reached atmospheric pressure before closing the valves. The canisters will be shipped to the offsite laboratory for analysis of the following VOCs that exceeded the historical drinking water USEPA Region 6 MSSLs during the OU-1 RI:

- Benzene
- CT
- Chloroform
- 1,2-DCA
- *cis*-1,2-DCE
- *trans*-1,2-DCE
- Methylene chloride
- Naphthalene
- Vinyl chloride
- 1,1,2,2-TeCA
- 1,1,2-TCA
- PCE
- TCE

1,1,1,2-TeCA was not included in the analyte list for subslab soil gas and indoor air and outdoor air samples because it is not reported in the analyte list for Method TO-15 nor the Compendium Method TO-15 (USEPA 1999), which adds compounds to the original Method TO-15. The omission of 1,1,1,2-TeCA in the reporting list is not considered a data gap because the chemical has not been detected in any offsite groundwater samples. The detectable presence of 1,1,1,2-TeCA was limited to one monitoring well, MW-111, located within the site boundaries of the former Hanley Area, which has since been treated via soil mixing with zero-valent iron during the OU-1 remedial action. Methylene chloride (degradation product of CT) was added at MDNR's request during the FS.

Tunnel Air Sampling

Tunnel air sampling will be conducted to achieve the DQO #6 presented in Worksheet #11, Project/Data Quality Objectives.

Field oversight activities will be performed by a two-person team consisting of the field team leader/QC officer and a field team member experienced in indoor air sampling. Because of the uncertainties associated with air quality in the tunnel system, qualified personnel will conduct tunnel air sampling activities.

CH2M HILL's subcontracted personnel will gain entry into the main tunnel system (following removal of the steel barrier blocking the entrance) using confined-space entry procedures and will assess the condition of the tunnel system and the feasibility of collecting tunnel air samples at the locations depicted in Figure 14. Following ROE approval from Job Corps, CH2M HILL will determine if entry into the small utility tunnel is possible.

CH2M HILL and its subcontracted personnel will deploy sample canisters for indoor air and ambient air sampling, in accordance with the SOP, *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*.

Individually certified 6-liter SUMMA canisters will be used to collect the indoor air samples and outdoor air samples. The canisters will be kept open for 24 hours using a flow controller set for 3.75 milliliters per minute, which will allow the SUMMA canister to fill over a 24-hour period.

For QC purposes, one FD sample of indoor air will be collected during the tunnel air sampling event.

On the second day of the tunnel air sampling event, CH2M HILL and its subcontracted personnel will return to the sample locations and will close the sample ports on the indoor air and ambient air SUMMA canisters. CH2M HILL will arrive before 24 hours have elapsed since the canisters were opened to ensure that the canisters have not

reached atmospheric pressure before closing the valves. The canisters will be shipped to the offsite laboratory for analysis of the VOCs identified in the aforementioned vapor intrusion assessment approach to achieve DQO #2.

Investigation-derived Waste Management

IDW management procedures are detailed in the FSP and are generally described in the following paragraphs.

IDW will be placed in 55-gallon steel drums approved by the U.S. Department of Transportation. The drums will be labeled (refer to the FSP for labeling procedures) and stored at a designated drum staging area at the former Hanley Area. The drums will be transported from the point of generation to the staging area following completion of groundwater grab sampling activities. IDW will be characterized to determine the appropriate means of transport and disposal. Nonhazardous solid waste will be profiled, manifested, transported, and disposed of at an appropriate offsite disposal facility. Material considered to be hazardous will be segregated from nonhazardous waste, profiled, manifested, and transported offsite as hazardous waste to a permitted hazardous waste facility, following USACE review and approval, and signature of the necessary paperwork by a DoD representative.

Purge water generated during well development activities, groundwater sampling, and decontamination fluids will be placed in a labeled 55-gallon drum and disposed of in the City of St. Louis combined stormwater and sanitary sewer collection system upon approval from the St. Louis Metropolitan Sewer District. Trash and personal protective equipment will be disposed of in a dumpster at the former Hanley Area.

Worksheet #18—Sampling Locations and Methods

The following table summarizes the sampling matrix, number of samples to be collected, analytical parameters, and the rationale for sampling location described in Worksheet #17 (*Sampling Design and Rationale*).

TABLE 18-1
Sample Locations and Sampling SOP Requirements
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
Seven Proposed Colocated Shallow and Deep Overburden Monitoring Well Pairs Along Stratford Avenue (includes MW-107 through MW-109) and at PP-17 to Achieve DQO #1 (Worksheet #11; Figure 10). One round of groundwater sampling of the existing monitoring wells is included.	SLOP-MW-106-xxxxxx	Groundwater	25	15-35	VOCs	23 primary samples, 3 FD, and 2 MS/MSD per sampling event The number of FD and MS/MSD samples are contingent upon the quantity of samples anticipated to be collected from all of the colocated monitoring well pairs to achieve DQOs #1, 3, 4, and 5.	SOP *Low-flow Groundwater Sampling* SOP *Water Sample Collection for Volatile Organic Compounds* SOP *Water Level Measurements*	Determine if site-related VOCs in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and evaluate if further action is warranted.
	SLOP-MW-107-xxxxxx		18.5	10-27				
	SLOP-MW-108-xxxxxx		18.5	10-27				
	SLOP-MW-109-xxxxxx		19	10-28				
	SLOP-MW-110-xxxxxx		19	10-28				
	SLOP-MW-112-xxxxxx		19	10-28				
	SLOP-MW-113-xxxxxx		18.5	10-27				
	SLOP-MW-114-xxxxxx		19	9-29				
	SLOP-MW-115-xxxxxx		38	33-43				
	SLOP-MW-116-xxxxxx		23	18-28				
	SLOP-MW-118-xxxxxx		31	26-36				
	SLOP-MW-119-xxxxxx		20	10-30				
	SLOP-MW-122-xxxxxx		TBD	TBD				
	SLOP-MW-123-xxxxxx		TBD	TBD				
	SLOP-MW-124-xxxxxx		TBD	TBD				
	SLOP-MW-126-xxxxxx		TBD	TBD				
	SLOP-MW-107S-xxxxxx		TBD	TBD				

TABLE 18-1

Sample Locations and Sampling SOP Requirements

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
	SLOP-MW-108S-xxxxxx		TBD	TBD				
	SLOP-MW-109S-xxxxxx		TBD	TBD				
	SLOP-MW-122S-xxxxxx		TBD	TBD				
	SLOP-MW-123S-xxxxxx		TBD	TBD				
	SLOP-MW-124S-xxxxxx		TBD	TBD				
	SLOP-MW-126S-xxxxxx		TBD	TBD				
One Proposed Colocated Shallow and Deep Overburden Monitoring Well Pair West of MW-118 and One Proposed Deep Monitoring Well East of MW-118 to Achieve DQO #3 (Worksheet #11; Figure 10)	SLOP-MW-120-xxxxxx SLOP-MW-121-xxxxxx	Groundwater	TBD TBD	TBD TBD	VOCs	3 primary samples, 1 FD, and 1 MS/MSD per sampling event The number of FD and MS/MSD samples are contingent upon the quantity of samples anticipated to be collected from all of the colocated monitoring well pairs to achieve DQOs #1, 3, 4, and 5.	SOP *Low-Flow Groundwater Sampling* SOP *Water Sample Collection for Volatile Organic Compounds* SOP *Water Level Measurements*	Confirm that the current LUC boundaries at Plume C (under OU-1) are protective of the groundwater direct contact pathway for construction workers or to refine the LUC boundary west and east of MW-118 after the western and eastern plume extent is determined.
	SLOP-MW-120S-xxxxxx		TBD	TBD				Determine if site-related VOCs in shallow groundwater west of MW-118 are potentially contributing to VI at the Job Corps facility and evaluate if the impacts warrant further action.
	TBD	Groundwater	TBD	TBD	VOCs			
	TBD		TBD	TBD				

TABLE 18-1

Sample Locations and Sampling SOP Requirements

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
Based on Groundwater Investigation Along Stratford Avenue (DQO #1), Three Proposed Colocated Shallow and Deep Overburden Monitoring Well Pairs Near Day Care Center to Achieve DQO #4 (Worksheet #11; Figure 10)	TBD		TBD	TBD		4 primary samples, 1 FD, and 1 MS/MSD per sampling event. The number of FD and MS/MSD samples are contingent upon the quantity of samples anticipated to be collected from all of the colocated monitoring well pairs to achieve DQOs #1, 3, 4, and 5.	SOP *Low-Flow Groundwater Sampling* SOP *Water Sample Collection for Volatile Organic Compounds* SOP *Water Level Measurements*	Determine if site-related VOCs in shallow groundwater along Stratford Avenue are above VISLs and evaluate if the impacts warrant action near the day care center.
	TBD		TBD	TBD				
One Proposed Colocated Shallow and Deep Overburden Monitoring Well Pair Furthest West Along Stratford Avenue to Achieve DQO #5 (Worksheet #11; Figure 10)	SLOP-MW-125-xxxxxx	Groundwater	TBD	TBD	VOCs	2 primary samples, 1 FD, and 1 MS/MSD per sampling event The number of FD and MS/MSD samples are contingent upon the quantity of samples anticipated to be collected from all of the colocated monitoring well pairs to achieve DQOs #1, 3, and 5.	SOP *Low-Flow Groundwater Sampling* SOP *Water Sample Collection for Volatile Organic Compounds* SOP *Water Level Measurements*	This well pair would be used to refine groundwater flow direction and to assess groundwater conditions.
	SLOP-MW-125S-xxxxxx		TBD	TBD				
VI Assessment at PP-2	PP02-SG-01-xxxxxx	Subslab Soil Gas	NA	NA	VOCs	2 primary subslab soil gas samples, 1 primary indoor air sample, 1 outdoor air sample, and 1 FD indoor air sample per VI assessment.	SOP *Collection of Subslab Gas Samples Using SUMMA Canisters* SOP *Collection of Subslab Gas Samples*	Determine if site-related VOCs in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and
	PP02-SG-02-xxxxxx	Subslab Soil Gas	NA	NA				
	PP02-IA-01-xxxxxx	Indoor Air	NA	NA				

TABLE 18-1

Sample Locations and Sampling SOP Requirements

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
	PP02-AA-01-xxxxxx	Outdoor Air	NA	NA		The number of FD samples are contingent upon the quantity of samples anticipated to be collected from all of the residences to achieve DQO #2.	*Using SUMMA Canisters – Alternate Method* SOP *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*	evaluate if further action is warranted.
VI Assessment at PP-3	PP03-SG-01-xxxxxx	Subslab Soil Gas	NA	NA	VOCs	1 primary subslab soil gas sample, 1 primary indoor air sample, 1 primary outdoor air sample, and 1 FD subslab soil gas sample per VI assessment. The number of FD samples are contingent upon the quantity of samples anticipated to be collected from all of the residences to achieve DQO #2.	SOP *Collection of Subslab Gas Samples Using SUMMA Canisters* SOP *Collection of Subslab Gas Samples Using SUMMA Canisters – Alternate Method* SOP *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*	Determine if site-related VOCs in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and evaluate if further action is warranted.
	PP03-IA-01-xxxxxx	Indoor Air	NA	NA				
	PP03-AA-01-xxxxxx	Outdoor Air	NA	NA				
VI Assessment at PP-4	PP04-SG-01-xxxxxx	Subslab Soil Gas	NA	NA	VOCs	Up to 2 primary subslab soil gas samples, 1 primary indoor air sample, 1 outdoor air sample, and 1 FD indoor	SOP *Collection of Subslab Gas Samples Using SUMMA Canisters*	Determine if site-related VOCs in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and
	TBD	Subslab Soil Gas	NA	NA				
	PP04-IA-01-xxxxxx	Indoor Air	NA	NA				

TABLE 18-1
Sample Locations and Sampling SOP Requirements
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
	PP04-AA-01-xxxxxx	Outdoor Air	NA	NA		air sample per VI assessment. The number of FD samples are contingent upon the quantity of samples anticipated to be collected from all of the residences to achieve DQO #2.	SOP *Collection of Subslab Gas Samples Using SUMMA Canisters – Alternate Method* SOP *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*	evaluate if further action is warranted.
VI Assessment at PP-5	PP05-SG-01-xxxxxx	Subslab Soil Gas	NA	NA	VOCs	Up to 2 primary subslab soil gas samples, 1 primary indoor air sample, 1 outdoor air sample, and 1 FD indoor air sample per VI assessment. The number of FD samples are contingent upon the quantity of samples anticipated to be collected from all of the residences to achieve DQO #2.	SOP *Collection of Subslab Gas Samples Using SUMMA Canisters* SOP *Collection of Subslab Gas Samples Using SUMMA Canisters – Alternate Method* SOP *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*	Determine if site-related VOCs in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and evaluate if further action is warranted.
	TBD	Subslab Soil Gas	NA	NA				
	PP05-IA-01-xxxxxx	Indoor Air	NA	NA				
	PP05-AA-01-xxxxxx	Outdoor Air	NA	NA				

TABLE 18-1

Sample Locations and Sampling SOP Requirements

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
VI Assessment at PP-17	PP17-SG-01-xxxxxx	Subslab Soil Gas	NA	NA	VOCs	2 primary subslab soil gas samples, 1 primary indoor air sample, 1 outdoor air sample, and 1 FD indoor air sample per VI assessment. The number of FD samples are contingent upon the quantity of samples anticipated to be collected from all of the residences to achieve DQO #2.	SOP *Collection of Subslab Gas Samples Using SUMMA Canisters* SOP *Collection of Subslab Gas Samples Using SUMMA Canisters – Alternate Method* SOP *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*	Determine if site-related VOCs in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and evaluate if further action is warranted.
	PP17-SG-02-xxxxxx	Subslab Soil Gas	NA	NA				
	PP17-IA-01-xxxxxx	Indoor Air	NA	NA				
	PP17-AA-01-xxxxxx	Outdoor Air	NA	NA				
Tunnel Air Sampling (Figure 14)	TUN-IA-01-xxxxxx	Indoor Air	NA	NA	VOCs	Up to 3 primary indoor air samples, 3 outdoor air samples, and 1 FD indoor air sample per VI assessment.	SOP *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*	Determine if site-related VOCs in shallow groundwater in the north portion of the former Hanley Area could contribute to VI at the adjacent Job Corps facility and evaluate if further action is warranted.
	TUN-AA-01-xxxxxx	Outdoor Air	NA	NA				
	TUN-IA-02-xxxxxx	Indoor Air	NA	NA				
	TUN-AA-02-xxxxxx	Outdoor Air	NA	NA				

TABLE 18-1

Sample Locations and Sampling SOP Requirements

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Sampling Location/Sample ID	Sampling ID	Matrix	Depth of Sample* (ft bgs)	Screen Interval (ft bgs)	Analytical Group	Estimated Number of Samples (identify FDs)	Sampling SOP Reference	Rationale for Sampling Location
	TUN-IA-03-xxxxxx	Indoor Air	NA	NA				
	TUN-AA-03-xxxxxx	Outdoor Air	NA	NA				

MS/MSD = matrix spike/matrix spike duplicate; NA = not applicable; xxxxxx = sample date; TBD = to be determined

* = Depth of sample assumes collection of groundwater samples at the midpoint of the screened interval if the screen is fully submerged. Groundwater samples will be collected at the midpoint of the water column if water is observed below the top of the screened interval.

Worksheet #19 and #30—Sample Containers, Preservation, and Hold Times

Worksheets #19 and #30 summarize the analytical methods for each sample matrix, including the required sample volume, containers, preservation, and holding time requirements. Further information on the laboratory analytical SOPs is provided in Worksheet #23 (*Analytical SOP References*).

TABLE 19-1
Sample Containers, Preservation and Hold Times—Empirical Laboratories, LLC
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Empirical Laboratories, LLC

Marcia McGinnity
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Nashville, TN 37228
Phone: 615.345.1115 ext. 232
E-mail: mmginnity@empirlabs.com

Certification: DoD ELAP
Accreditation Expiration: Expiring November 30, 2015
Sample Delivery Method: FedEx Overnight services
Data Deliverable: 21 Calendar Days

Matrix	Analytical Group	Analytical and Preparation Method	Containers	Quantity	Preservation Requirements	Maximum Holding Time
Groundwater	VOCs	SW8260B/SW5030	40-milliliter volatile organic analysis (VOA) vials	3	No headspace; 4 ± 2 degrees Celsius, pH less than 2 with HCL	14 days from data of collection

TABLE 19-2
Sample Containers, Preservation and Hold Times—Applied Sciences Laboratory
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Applied Sciences Laboratory

Ben Thompson
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Phone: (541) 768-3132
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Certification: DoD ELAP
Accreditation Expiration: September 2014
Sample Delivery Method: FedEx Overnight services
Data Deliverable: 21 Calendar Days

Matrix	Analytical Group	Analytical and Preparation Method	Containers	Quantity	Preservation Requirements	Maximum Holding Time
Subslab soil gas, indoor air, and outdoor air	VOCs	TO-15 SIM	6L Summa Canister	1	NA	Analyze within 30 days of sample collection

Notes:
L = liter; SIM = select ion mode

Worksheet #20—Field QC Sample Summary

Field QC sampling requirements and procedures are specified in Section 5.2 of the FSP. The table below provides a summary of the types of samples to be collected and analyzed during the initial phase of the RI (based on results of the initial phase of the RI, additional sampling may be required). Its purpose is to show the relationship between the number of field samples and associated QC samples for each combination of analyte/analytical group and matrix.

Matrix	Analyte/Analytical Group	Field Samples	Field Blanks	FDs	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Other	Total # Analyses
Groundwater	VOCs	32	1	4	2	2	0	3	5	N/A	48
Subslab Soil Gas	VOCs	Up to 9	0	1	0	0	0	0	0	N/A	10
Indoor Air	VOCs	5	0	1	0	0	0	0	0	N/A	6
Outdoor Air	VOCs	Up to 8	0	0	0	0	0	0	0	N/A	8
Tunnel Air	VOCs	Up to 3	0	1	0	0	0	0	0	N/A	4

Worksheet #21—Field SOPs

The field SOPs associated with the project sampling (including, but not limited to, sample collection and sample handling and custody) are provided in the FSP (Appendix C).

Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection

Field equipment and instruments to be used during the field investigation requiring calibration, maintenance, testing, or inspection include a photoionization detector, a helium leak detector, a water-level indicator, a GPS unit, and a water quality multi-parameter monitor. The frequency of calibration, maintenance, testing and inspection, as well as any necessary corrective action will be in accordance with the manufacturer's manual. A calibration log is provided in the FSP (Appendix C).

Worksheet #23—Analytical SOP References

The following LSOP references were provided by Empirical Laboratories and Applied Sciences Laboratory. Note that the LSOPs have not been modified specifically for this project and may not reflect the exact requirements of this document. The LSOPs are supplemented by internal communication systems within the laboratory to disseminate the project requirements and UFP-QAPP to technical staff. LSOPs are provided as Appendix B.

Reference Number	Title, Revision Number, and Date	Definitive/ Screening Data	Matrix/ Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
LSOP-01	GC/MS volatiles by Method E624 and SW846, Method 8260B, including Appendix IX compounds. Revision 23. September 2012.	Definitive	Water: VOCs	GC/MS	Empirical Laboratory	N
LSOP-02	Analytical method for the determination of volatile organic compounds in air by Method TO-14A/TO-15 using canisters and GC/MS in Scan or SIM Mode. Revision 13. March 2012.	Definitive	Vapor: VOCs	GC/MS	Applied Sciences Laboratory	N

GC/MS = gas chromatography/mass spectrometry

Worksheet #24—Analytical Instrument Calibration

To confirm that the analytical methods and the selected instrumentation meet the project requirements, each analytical instrument will be calibrated according to the procedures outlined in the tables provided in Worksheet #28 (*Analytical Quality Control and Corrective Action*). Worksheets #24 and #28 have been combined together for efficiency and ease of use to the CH2M HILL project chemist and the laboratory. The information provides documentation on corrective actions, flagging criteria for laboratory services, and expectations for analytical services. Tables meet the requirements of both Worksheet #28 (*Analytical Quality Control and Corrective Action*) and Worksheet #24 (*Analytical Instrument Calibration*). Tables are presented by method and reflect the requirements of the DoD QSM Version 4.2 (DoD 2010) and individual method requirements.

Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection

To confirm that the analytical instrument and equipment are available and in working order when needed, all laboratory analytical equipment will be maintained and tested in accordance with procedures described in the LSOPs (Appendix B).

Worksheet #26 and #27—Sampling Handling, Custody, and Disposal

To verify sample authenticity and data defensibility, a complete sample handing system will be followed from the time of sample collection to final sample disposal.

The field team leader or designee will be responsible for the sample collection, sample packing, and coordination of sample shipment. The samples will be sent to the respective laboratories by Federal Express overnight. Detailed information regarding sample handling, custody, and shipping requirements for the field staff are provided in the FSP (Appendix C). Laboratory procedures are summarized in the following subsections.

Laboratory Sample Custody Procedures

A designated laboratory representative will accept the shipped samples and verify that the received samples match those on the chain-of-custody record. The condition, temperature, and appropriate preservation of the samples should be checked and documented on the chain-of-custody form. The occurrence of any anomalies in the received samples and their resolution should be documented in the laboratory records. All sample information will then be entered into a tracking system, and unique analytical sample identifiers will be assigned. The laboratory will review this information for accuracy.

The laboratory must supply sample receipt confirmation within 24 hours of sample receipt that includes the following:

- A fully executed copy of the chain-of-custody received with the samples
- Sample acknowledgement letter and log-in report
- Cooler and sample receipt form noting any problems, breakages, holding time issues, temperature exceedances, inconsistencies between the chain of custody, purchase order, and project instructions, etc.

Sample holding-time tracking begins with the collection of samples and continues until the analysis is complete. Holding times for analytical methods required for this project are specified in Worksheet #19 and #30 (*Sample Containers, Preservation and Hold Times*). Subcontracted analyses will be documented with the chain-of-custody form. Procedures ensuring internal laboratory chain-of-custody also will be implemented and documented by the laboratory. Specific instructions concerning the analysis specified for each sample will be communicated to the analysts. Analytical batches will be created, and laboratory QC samples will be introduced into each batch.

Samples will be stored in limited-access, temperature-controlled areas. Refrigerators, coolers, and freezers will be monitored for temperature 7 days a week. Acceptance criterion for the temperatures of the refrigerators and coolers is 4 plus or minus 2 degrees Celsius. Acceptance criterion for the temperatures of the freezers is lower than minus 7 degrees Celsius. All of the cold storage areas will be monitored by thermometers that have been calibrated with a National Institute Standards and Technology (NIST)-traceable thermometer. As indicated by the findings of the calibration, correction factors may be applied to each thermometer. Records regarding acceptance criteria will be maintained.

Samples will be stored for 30 days after analysis and reporting, at which time the samples will be disposed of. The samples will be disposed of in accordance with applicable local, state, and federal regulations. Disposal records will be maintained by the laboratory. SOPs describing sample control and custody will be maintained by the laboratory.

Worksheet #28—Analytical Quality Control and Corrective Action

Worksheet #28 presents analytical QC requirements relevant to analysis of environmental samples that will be followed by laboratories producing definitive data. The purpose of the laboratory QC activities is to produce data of known quality sufficient to meet the project-specific DQOs. Laboratory QC samples will follow method specific requirements of the DoD QSM version 4.2 (Appendix F of the QSM; DoD 2010) and/or the analytical method and are presented in Table 28-1 and 28-2.

Laboratory QC samples must be included in an analytical batch with the field samples. An analytical batch is a group of samples (not exceeding 20 environmental samples plus associated laboratory QC samples) similar in composition (matrix) that are extracted or digested at the same time and with the same lot of reagents and analyzed together as a group. The analytical batch also extends to cover samples that do not need separate extraction or digestion. The identity of each analytical batch will be unambiguously reported with the analyses so that a reviewer can identify the laboratory QC samples and the associated environmental samples. The type of laboratory QC samples and the frequency of use of these samples are discussed below and in method-specific LSOPs.

Detection Limits

The DLs will be completed for all target analytes and matrices in accordance with the DoD QSM Version 4.2 (DoD 2010). The laboratory will establish DLs for each method, matrix, and analyte. The information has been provided in tables of Worksheet #15. The DL is used along with other measurements of sensitivity, such as the LOD and LOQ.

If multiple instruments are used, the DL used for reporting purposes will represent the least sensitive instrument response for each compound or element spiked.

Limit of Detection

The DL will be used to determine the LOD for each analyte and matrix and for all preparatory and cleanup methods routinely used on samples, as follows. After each DL determination, the laboratory must immediately establish the LOD by spiking a quality system matrix at approximately two to three times the DL (for a single-analyte standard) or one to four times the DL (for a multi-analyte standard). The spike concentration establishes the LOD; it is specific to each combination of analyte, matrix, method (including sample preparation), and instrument configuration. The LOD must be verified quarterly.

The following requirements apply to the initial DL and LOD determinations and to the quarterly LOD verifications:

- The apparent signal-to-noise ratio at the LOD must be at least 3, and the results must meet all method requirements for analyte identification (for example, ion abundance, second-column confirmation, or pattern recognition). For data systems that do not provide a noise measurement, the signal produced by the verification sample must produce a result that is at least three standard deviations greater than the mean method blank concentrations.
- If a laboratory uses multiple instruments for a given method, the LOD must be verified for each instrument.
- If the LOD verification fails, the laboratory must repeat the DL determination and LOD verification at a higher concentration, or perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration.

The laboratory will maintain documentation for all DL determinations and LOD verifications.

Limit of Quantitation

The range at which quantitative results may be obtained with a specified degree of confidence for the method is referred to as the LOQ. The laboratory will verify LOQs by including a standard equal to or below the LOQ as the lowest point on the calibration curve.

If a result is greater than the DL and less than the LOQ, the result will be reported as a detected concentration and flagged "J." If no detected concentration is determined down to the DL, the result will be reported to the LOQ concentration (with the added variables of sample dilution, final volume, and sample mass included), reported as a nondetect result, and flagged "U." A detected result greater than or equal to the LOQ will be reported without a qualifying flag unless a specific QA/QC failure is associated with the data. No results below the DL will be reported.

At a minimum, the LOQ must be verified quarterly. The laboratory procedure for establishing the LOQ must empirically demonstrate precision and bias at the LOQ. The LOQ and associated precision and bias must meet project-specific requirements and must be reported. If the method is modified, precision and bias at the new LOQ must be demonstrated and reported.

DLs, LODs, and LOQs are provided in Worksheet #15 (*Project Action Limits and Laboratory Specific Detection/Quantitation Limits*). LODs are expected to be two to three times greater than the DL and below the LOQ. The DLs, LODs, LOQs were compared to the project-specific screening criteria to determine whether they will meet the analytical DQOs. If the DL or the LOD is below the screening criterion, the LOQ is sufficient for project decision making. Otherwise, other analyte-specific factors (for example, potential use at the site, mobility, or toxicity) may be discussed in the PQOs on a more qualitative basis.

Sample dilution because of target and or non-target compound concentrations or matrix interference could prevent LOQs from being achieved. Samples initially must be analyzed while undiluted when reasonable. If dilution is necessary, both the original and diluted results must be reported. Any samples that are not analyzed undiluted must have the express approval of CH2M HILL within extraction and analysis holding time and be supported by matrix interference documentation, such as sample viscosity, color, odor, or results from other analyses of the same sample, to show that undiluted analysis is not possible. Appropriate cleanup procedures must be followed to minimize matrix effects on LOQs.

Calibration

All analytes reported must be present in the initial and continuing calibrations. The calibrations must meet the acceptance criteria specified in the tables provided in this QAPP. All results reported must be within the calibration range. Samples will be diluted, if necessary, to bring analyte responses within the calibration range. Records of standard preparation and instrument calibration will be maintained. Records must unambiguously trace the standards and their use in calibration and quantitation of sample results.

Instrument calibration will be performed by beginning with the simplest approach first, the linear model through the origin, and then progressing through other options until the acceptance criteria are met. In cases where an analyte has more than one acceptable calibration model, results from the simplest calibration model will be reported. If more than the minimum number of standards is analyzed for the initial calibration (ICAL), all of the standards analyzed will be included in the ICAL. The only exception to this rule is that a standard at either end of the calibration curve can be dropped from the calibration, providing that the requirement for the minimum number of standards is met and the low point of the calibration curve is at or below the reporting limit (RL) for each analyte.

Calibrations must use the simplest calibration model first. Non-linear calibration will be considered only when a linear approach cannot be applied. It is not acceptable to use an alternate calibration procedure when a compound fails to perform in the usual manner. When this occurs, it is indicative of instrument issues or operator error.

The continuing calibration verification (CCV) cannot be used as the laboratory control sample (LCS), except for methods that do not involve sample preparation. A CCV will be performed daily before sample analysis (unless an ICAL and second-source standard verification is performed immediately before sample analysis) and as required by the applicable method. In accordance with National ELAP requirements, the laboratory will analyze the CCV concentration to vary throughout the calibration range. Finally, the lowest standard used must be at or below the RL for each analyte in the method.

Laboratory Control Samples

An LCS is a sample of known composition that is spiked with all target analytes. The LCS is used with each analytical batch to determine whether the method is in control. Each analyte in the LCS will be spiked at a level less than or equal to the midpoint of the calibration curve, which is defined as the median point of the curve instead of the middle of the range. The LCS will be carried through the complete sample preparation and analysis procedure. Except for VOC analysis, the LCS cannot be used as the CCV.

At least one LCS will be included in every analytical batch. If more than one LCS is analyzed in an analytical batch, results from all LCSs will be reported. Failure of an analyte in any LCS will necessitate appropriate corrective action, including qualification of the failed analyte in all of the samples, as required.

LCS Control Limits

The LCS limits specified in Worksheet #15 (*Project Action Limits and Laboratory Specific Detection/Quantitation Limits*) will be used for this project. The LCS limits are based on those specified in the DoD QSM Version 4.2 (DoD 2010). Laboratory historical control limits will be used for methods not listed in the DoD QSM.

The performance of the LCS is evaluated against the QC acceptance limits. When an analyte in the LCS is outside the acceptance limit, corrective action will be performed.

Marginal Exceedance

The laboratory may not use marginal exceedances as part of their data review practice, but are encouraged to contact the CH2M HILL project chemist to discuss compound-specific failures as needed.

Matrix Spike/Matrix Spike Duplicate

An MS or MSD is an aliquot of sample collected in the field and spiked with known masses and concentrations of all target analytes in the laboratory. The spiking will occur before sample preparation and analysis. Each analyte in the MS and MSD must be spiked at a level less than or equal to the midpoint of the calibration curve for that analyte. The MS/MSD is used to document potential matrix effects associated with a site and will not be used to control the analytical process. The MS/MSD results and flags will not be associated with or related to samples that are collected from the same site where the MS/MSD set were collected. The field team leader will select the samples for MS/MSDs and the laboratory will use the samples to prepare the appropriate MS/MSDs.

The performance of the MS and MSD will be evaluated against the QC acceptance limits outlined in Worksheet #15 (*Project Action Limits and Laboratory Specific Detection/Quantitation Limits*). If either the MS or the MSD is outside the QC acceptance limits, the data will be evaluated to determine whether there is a matrix effect or analytical error, and the analytes in the parent sample and associated FD (if applicable) will be qualified according to the data flagging criteria of this QAPP.

If the sample concentration exceeds the spike concentration by a factor of four or more, the data will be reported unflagged. The laboratory should communicate potential matrix difficulties to the CH2M HILL project chemist so an evaluation can be made with respect to the project-specific DQOs.

Surrogates

Surrogates are compounds similar to the target analytes in chemical composition and behavior in the analytical process, but not normally found in environmental samples. Surrogates are used to evaluate accuracy, method

performance, and extraction efficiency. Surrogates will be added to environmental samples, controls, and blanks, in accordance with the method requirements.

If a surrogate recovery is outside the acceptance limit, corrective action must be performed. After the system problems have been resolved and system control has been re-established, the sample will be re-prepared and re-analyzed. If corrective actions are not performed or are ineffective, an appropriate flag will be applied to the sample results. Surrogate spikes that have been diluted out will not be flagged.

Internal Standards

Internal standards are known amounts of standards that are added to a portion of a sample or sample extract and carried through the entire determination procedure. They are used as a reference for calibration and for controlling the precision and bias of the analytical method. Internal standards will be added to environmental samples, controls, and blanks, in accordance with the method requirements.

If the results of the internal standards are outside of the acceptance limits, corrective actions will be performed. After the system problems have been resolved and system control has been reestablished, all samples analyzed while the system was malfunctioning will be re-analyzed. If corrective actions are not performed or are ineffective, an appropriate flag will be applied to the sample results.

Retention Time Windows

Retention time (RT) windows are used in gas chromatography (GC), ion chromatography, and high-performance liquid chromatography analysis for qualitative identification of analytes. They are calculated from replicate analyses of a standard on multiple days. The procedure and calculation method are given in SW-846, Method 8000C. The center of the RT window is established for each analyte and surrogate using the RT of the midpoint standard of the ICAL. For non-MS methods, they are updated daily using the absolute RT in the ICAL verification.

If the RT is outside the acceptance limits, corrective action will be performed—this applies to all CCV subsequent to the ICAL verification and to LCSs. If corrective actions are not performed or are ineffective, an appropriate flag will be applied to the sample results.

Method Blank

A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is carried through the complete sample preparation and analytical procedure, and is used to assess potential contamination resulting from the analytical process.

A method blank will be included in every analytical batch. The presence of analytes in a method blank at concentrations greater than the LOD indicates the need for further assessment of the data. The source of contamination will be investigated and measures will be taken to correct, minimize, or eliminate the problem if the concentration exceeds one-half the LOQ. For common laboratory contaminants (for example, methylene chloride, acetone, or phthalates), the method blank must not exceed the LOQ. No analytical data will be corrected for the presence of analytes in blanks.

If an analyte is detected in the method blank and in the associated samples and corrective actions are not performed or are ineffective, an appropriate flag may be applied to the sample results.

Quality Control Checks

Holding-time Compliance

All sample preparation and analyses will be performed within the method-required holding times, except as noted in Worksheet #19 (*Sample Containers, Preservation and Hold Times*). Some methods have more than one holding-time requirement (for example, Method SW8260C). For methods not requiring sample preparation, holding time is calculated from the time of sample collection to the time of completion of all

analytical runs. For methods requiring sample preparation before analysis, holding time is calculated from the time of preparation completion to the time of completion of all analytical runs.

Holding times are determined based on days, hours, and minutes. If the time of sample collection is not provided, the laboratory must assume the most conservative time of day. If holding times are exceeded and the analyses are performed, the results must be flagged according to the procedures described in this worksheet, except as noted in a table within Worksheet #19 (*Sample Containers, Preservation and Hold Times*) and identified in the data-package case narrative.

Standard Materials

Standard materials (including second source materials) used in calibration and sample preparation must be traceable to NIST, USEPA, American Association of Laboratory Accreditation (A2LA), or other equivalent approved source, if available. If an NIST, USEPA, or A2LA standard material is not available, the standard material proposed for use must be included in an addendum to the project-specific QAPP and approved before use.

The standard materials must be current, and the following expiration policy must be followed:

- Expiration dates for amputated solutions should not exceed the manufacturer's expiration date or one year from the date of receipt, whichever comes first.
- Expiration dates for laboratory-prepared stock and diluted standards must be no later than the expiration date of the stock solution or material or the date calculated from the holding time allowed by the applicable analytical method, whichever comes first.
- Expiration dates for pure chemicals will be established by the laboratory and be based on chemical stability, possibility of contamination, and environmental and storage conditions.
- Expired standard materials will be either re-validated before use or discarded. Re-validation may be performed through assignment of a true value and error window statistically derived from replicate analyses of the material as compared to an unexpired standard. The laboratory will label standard and QC materials with expiration dates.

A second source standard will be used to independently confirm the ICAL. A second source standard is a standard purchased from a vendor different from that supplying the material used in the ICAL. The second source material can be used for the continuing calibration standards and/or for the LCS. Two different lot numbers from the same vendor do not normally constitute a second source. However, when a project requires analyses for which there is not a separate vendor source available, the use of different lot numbers from the same vendor will be acceptable to verify calibration.

Supplies and Consumables

The laboratory will inspect supplies and consumables before their use in analysis. The materials description in the methods of analysis will be used as a guideline for establishing the acceptance criteria for these materials. Purity of reagents will be monitored and documented. An inventory and storage system for these materials will assure use before manufacturers' expiration dates and storage under safe and chemically compatible conditions.

TABLE 28-1

Summary of Calibration and Quality Control Procedures for Method SW8260B

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]	Flagging Criteria[b]
Mass spectrometer tuning check Use bromofluorobenzene	Before ICAL and calibration verification	Refer to criteria listed in method description.	Retune instrument and verify.	Not appropriate.
Multipoint ICAL for all analytes (minimum five standards)	Before sample analysis	Average response factor (RF) for SPCCs: ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-DCA. RSD for RFs for CCCs: ≤ 30% and one option below: Option 1: Linear—RSD for each analyte < 15%. Option 2: Linear—linear least squares regression r > 0.995 for each analyte. Option 3: Nonlinear—COD ≥ 0.99 (6 points will be used for second order, 7 points will be used for third order). Non-linear calibrations models are not a preferred option and must only be used for compounds that typically will not demonstrate a linear model.	Correct problem, then repeat ICAL.	Problem must be corrected. Samples may not be analyzed until there is a valid ICAL. Calibration may not be forced through the origin.
Second-source calibration verification	Once per ICAL	All analytes within ± 20% of expected value.	Correct problem and verify second-source standard. Rerun second-source verification. If that fails, correct problem and repeat ICAL.	Problem must be corrected. Samples may not be analyzed until the calibration has been verified.
RT window position establishment for each analyte and surrogate	Once per ICAL	Position will be set using the midpoint standard of the ICAL curve. On days when an ICAL is not performed, the CCV is used.	NA.	NA.
RT window verification for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of ICAL. Laboratories may update the RTs based on the CCV to account for minor performance fluctuations or after routine system maintenance (for example, column clipping. With each sample, the RRT will be compared with the most recently updated RRT. If the RRT has changed by more than ±0.06 RRT units since the last update, there has been a significant change in system performance and the laboratory must take appropriate corrective actions as required by the method and rerun the ICAL to re-establish the RTs.	Correct problem then reanalyze all samples analyzed since the last RT check.	Not appropriate, no target compounds are to be reported when the RRT is out of control.

TABLE 28-1

Summary of Calibration and Quality Control Procedures for Method SW8260B

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]	Flagging Criteria[b]
CCV	Daily, before sample analysis (unless ICAL performed on same day), and after every 12 hours of analysis time	Average RF for SPCCs : ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-DCA. All analytes within ± 20% D of expected value from ICAL.	Correct problem, then rerun CCV. If that fails, repeat ICAL.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to all results for the specific analyte(s) in all samples since last acceptable CCV
ISs	Each sample, standard, and QC sample	RT ± 30 seconds from RT of the internal standards in the ICAL midpoint standard. Extracted ion current profile area within -50% to +100% of area from internal standards in ICAL mid-point standard.	Inspect mass spectrometer and GC for malfunctions and make corrections as appropriate. Reanalysis of samples analyzed while the system was malfunctioning is mandatory.	Apply Q-flag to all results for analytes associated with a failed internal standards (unless a matrix effect can be verified), then apply M-flag.
Method blank	One per analytical batch	No analytes detected > ½ LOQ. For common laboratory contaminants, no analytes detected > LOQ. See Worksheet #36.	Assess data. Correct problem. If necessary, reprepare and analyze method blank and all samples processed with the contaminated blank.	Apply B-flag to all associated positive results for the specific analyte(s), as appropriate. See Worksheet #36.
LCS for all analytes	One LCS per analytical batch	Acceptance criteria: Worksheet #15.	Correct problem, then reanalyze. If still out, reprepare and reanalyze the LCS and all samples in the affected batch.	If corrective action fails, apply Q-flag to the specific analyte(s) in all samples in the associated preparatory batch.

TABLE 28-1

Summary of Calibration and Quality Control Procedures for Method SW8260B

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]	Flagging Criteria[b]
MS/MSD	One per 20 samples per matrix as a minimum and as defined on the chain-of-custody form	Acceptance criteria: Worksheet #15.	Assess data to determine whether there is a matrix effect or analytical error. Analyze LCS for failed target analytes. Potential matrix effects should be communicated to CH2M HILL so an evaluation can be made regarding the PQOs.	For the specific analyte(s) in all samples collected from the same site matrix as the parent, apply J-flag if: (1) %R for MS or MSD > upper control limit (2) %R for MS or MSD < lower control limit (3) MS/MSD RPD > control limit
Surrogate spike	Every sample, spiked sample, standard, and method blank	Acceptance criteria: Worksheet #15.	Correct problem, then reprepare and reanalyze the affected samples. If matrix effect is verified, discuss in case narrative.	Apply Q-flag to all associated analytes if acceptance criteria are not met.
DL study (as part of the LOD process; see Section D.1.2.1 of the DoD QSM[c])	At initial setup and then once per 12-month period or quarterly DL verification	DLs established in accordance with the DoD QSM Version 4.2. All analytes must be detected and identified by method-specified criteria for the verification check to be valid, or the verification check must produce a response that is at least 3 times the instrument noise level and greater than the response in the blanks associated with the DL study.	Continue the DL study until all criteria are met.	NA.

TABLE 28-1

Summary of Calibration and Quality Control Procedures for Method SW8260B

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]	Flagging Criteria[b]
LOD determination and verification (see Section D.1.2.1 and Box D-13 of the DoD QSM[c])	At initial setup and verified quarterly (if a laboratory uses multiple instruments for a given method, the LOD must be verified on each)	The apparent signal-to-noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must (1) repeat the DL determination and LOD verification at a higher concentration or (2) perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	NA; samples may not be analyzed without a valid LOD.
LOQ establishment and verification (see Section D.1.2.2 and Box D-14 of the DoD QSM[c])	At initial setup: (1) verify LOQ; and (2) determine precision and bias at the LOQ; then verify LOQ quarterly (if a laboratory uses multiple instruments for a given method, the LOQ must be verified on each; see Box D-14 of DoD QSM[c]	(1) The LOQ and associated precision and bias must meet client requirements and must be reported, or (2) in the absence of client requirements, must meet LCS control limits. See Box D-14 of the DoD QSM.[c]	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	NA; samples may not be analyzed without a valid LOQ.
Results reported between the DL and LOD, and the LOD and LOQ	None	None.	None.	Apply J-flag to all results between DL and LOQ. If no result below the LOQ, report to the LOD, flag "U."

TABLE 28-1

Summary of Calibration and Quality Control Procedures for Method SW8260B

UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]	Flagging Criteria[b]
Demonstrate acceptable analyst capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, or test method (see Appendix C of DoD QSM [c])	QC acceptance criteria published by DoD, if available; otherwise method-specified criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f of the DoD QSM[c]).	NA. This is a demonstration of ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample (for example, LCS or PT sample). No analysis will be allowed by an analyst until capability is demonstrated.

[a]Corrective actions associated with project work will be documented, and records will be maintained by the laboratory. The analysis technician is responsible for corrective actions.

[b]Flagging criteria will be applied when acceptance criteria were not met and corrective action was not successful or corrective action was not performed.

[c]DoD. 2010. *DoD Quality Systems Manual for Environmental Laboratories*. Version 4.2. October.

Notes:

D = difference when using RFs or drift when using least square, regression, or nonlinear calibration

RRT = relative retention time

RSD = relative standard deviation

1

TABLE 28-2
Summary of Calibration and Quality Control Requirements for TO-15 SIM
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Frequency	Criteria	Corrective Action[a]	Flagging Criteria
BFB Tune Check	Once per 24-hour tune window	Must meet the method tune criteria	Re-tune.	Not appropriate.
Multi-Point Initial Calibration (minimum five points)	Prior to sample analysis, or when calibration verification fails	%RSD of ≤ 30%	Correct the problem and repeat the ICAL.	Problem must be corrected. Samples may not be analyzed until there is a valid ICAL. Calibration may not be forced through the origin.
Initial Calibration Verification	Once following each ICAL	Analytes within ±30% of expected value	Reanalyze. If still unacceptable, correct the problem and repeat the ICAL.	Problem must be corrected. Samples may not be analyzed until there is a valid ICAL.
CCV	At the start of each analytical sequence	Analytes within ±30% of expected value	Reanalyze. Correct the problem, then recalibrate and reanalyze all samples.	Apply Q-flag to all results for the specific analyte(s) > 30% D for all samples associated with the calibration verification.
Method Blank	At least one per analytical batch	No analytes detected at or above the LOQ	Reanalyze. If still unacceptable, reanalyze the blank and all samples in the analytical batch. If still unacceptable, flag all associated data in the analytical batch.	Apply B-flag to all associated positive results for the specific analyte(s) as appropriate. See Worksheet #36.
Surrogate spike	Every standard, sample, method blank, and LCS	Acceptance criteria: Worksheet #15	Reanalyze. If still unacceptable, flag all associated data in the analytical batch.	Apply Q-flag to all associated analytes if acceptance criteria are not met.
LCS	At least one per analytical batch	Acceptance criteria: Worksheet #15	Reanalyze. If still unacceptable, correct the problem and reanalyze the LCS and all samples in the analytical batch. If still unacceptable, flag all associated data in the analytical batch.	If corrective action fails, apply Q-flag to the specific analyte(s) in all samples in the associated preparatory batch.
Laboratory Duplicate	At least one per analytical batch	RPD ± 25%	Reanalyze. If still unacceptable, flag all associated data in the analytical batch.	If corrective action fails, apply J-flag to the specific analyte(s) in the sample.
Canister/Flow Controller Certification (Individual)	Prior to sampling	Canisters/Flow Controllers must be certified clean to the DL for each analyte	None	Not applicable.

TABLE 28-2
Summary of Calibration and Quality Control Requirements for TO-15 SIM
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Frequency	Criteria	Corrective Action[a]	Flagging Criteria
DL Study (as part of the LOD process; see Section D.1.2.1 of the DoD QSM)	At initial setup and then once per 12-month period or quarterly DL verification	DLs established in accordance with the DoD QSM Version 4.2. All analytes must be detected and identified by method-specified criteria for the verification check to be valid, or the verification check must produce a response that is at least 3 times the instrument noise level and greater than the response in the blanks associated with the DL study.	Continue the DL study until all criteria are met.	NA.
LOD Determination and Verification (see Section D.1.2.1 and Box D-13 of the DoD QSM)	At initial setup and verified quarterly (if a laboratory uses multiple instruments for a given method, the LOD must be verified on each)	The apparent signal-to-noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must (1) repeat the DL determination and LOD verification at a higher concentration, or (2) perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	NA; samples may not be analyzed without a valid LOD.
LOQ Establishment and Verification (see Section D.1.2.2 and Box D-14 of the DoD QSM)	At initial setup: (1) verify LOQ; and (2) determine precision and bias at the LOQ; then verify LOQ quarterly (if a laboratory uses multiple instruments for a given method, the LOQ must be verified on each; see Box D-14 of DoD QSM.	(1) The LOQ and associated precision and bias must meet client requirements and must be reported, or (2) in the absence of client requirements, must meet LCS control limits. See Box D-14 of the DoD QSM.	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	NA; samples may not be analyzed without a valid LOQ.

TABLE 28-2
Summary of Calibration and Quality Control Requirements for TO-15 SIM
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Check	Frequency	Criteria	Corrective Action[a]	Flagging Criteria
Results reported between the DL and LOD, and the LOD and LOQ	None	None	None	Apply J-flag to all results between DL and LOQ. If no result below the LOQ, report to the LOD, flag "U."
Demonstrate acceptable analyst capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, or test method (see Appendix C of DoD QSM).	QC acceptance criteria published by DoD, if available; otherwise method-specified criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f of the DoD QSM.	NA. This is a demonstration of ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample (for example, LCS or PT sample). No analysis will be allowed by an analyst until capability is demonstrated.

[a]Corrective actions associated with project work will be documented, and records will be maintained by the laboratory. The analysis technician is responsible for corrective actions.

Worksheet #29—Project Documents and Records

The required data package deliverables during every aspect of the project are identified in this worksheet, which include, but are not limited to the following: (1) sample collection and field measurement records, (2) analytical records, and (3) data assessment records.

Sample Collection and Field Measurement Records

Sample collection and field measurement records generally include field logbooks, photo documentation, equipment decontamination records, sampling instrument calibration records, boring logs, well construction diagrams, correspondence, chain-of-custody forms, and air bills.

The FSP (Appendix C) describes the procedures used to track field samples and identifies documentation procedures, project file requirements, and project-related reporting.

Analytical Records

Analytical Data Deliverables

Hard-copy deliverables must be provided with a summary format forms package, equivalent to those specified in the latest versions of USEPA Contract Laboratory Program Statements of Work for Organics Analyses or Contract Laboratory Program-like as long as the format provides summarized, form oriented reporting , meet all method specifications, and are fully able to be validated. Reporting formats require approval from the CH2M HILL project chemist. The following information will be provided in the data package：

- Cover letter complete with the following information:
  - Report title and laboratory unique report identification (sample delivery group number)
  - Project name and site location
  - Name and location of laboratory and second-site or subcontracted laboratory
  - Client name and address
  - Statement of authenticity and official signature and title of person authorizing report release.
- Table of contents
- Case narrative that addresses the following information at a minimum:
  - Sample receipt discrepancies that may affect data usability, such as bubbles in the groundwater samples, temperature exceedances, etc.
  - Table summarizing samples received, correlating field sample numbers, laboratory sample numbers, and laboratory tests completed
  - Descriptions of nonconformances in the sample receipt, handling, preparation, analytical, and reporting processes and the corrective action taken in each occurrence
  - Identification of samples and analytes for which manual integration was necessary
  - Identification and justification for sample dilution
  - Discussion of all qualified data and definition of qualifying flags
- Field identification number
- Date received
- Date prepared

- Date analyzed (and time of analysis if the holding time is less than or equal to 48 hours)
- Preparation and analytical methods
- Result for each analyte (dry weight basis for soils)
- Percent solids results for soil samples
- Dilution factor (provide both diluted and undiluted results when available)
- Sample-specific RL adjusted for sample size, dilution/concentration
- Sample-specific DL adjusted for sample size, dilution/concentration (when project objectives require reporting less than the RL)
- Units
- Surrogate percent recoveries
- MS/MSD and LCS spike concentrations, native sample results, spiked sample results, percent recoveries, and RPD between the MS and MSD results; Associated QC limits also must be provided
- Method blank results
- Analytical batch reference number that cross references samples to QC sample analyses
- Analytical sequence or laboratory run log that contains sufficient information to correlate samples reported in the summary results to the associated method QC information, such as initial and continuing calibration analyses
- Internal standard recovery and RT information, as applicable
- Initial calibration summary, including standard concentrations, RFs, average RFs, RSDs or correlation coefficients, and calibration plots or equations, if applicable
- CCV summary, including expected and recovered concentrations and percent differences
- Instrument tuning and mass calibration information for GC/mass spectrometry
- Other method-specific QC sample results
- Sample preparation logs that include the following information (provided on CD when requested):
  - Preparation start and end times
  - Beginning and ending temperatures of water baths, digestion blocks, etc.
- Example calculation for obtaining numerical results from at least one sample for each matrix analyzed; provide algorithm (provided on CD when requested)
- Reconstructed total ion chromatograms or selected ion current profiles for each sample (or blank) analyzed and mass spectra for each compound identified, including (provided on CD when requested):
  - Raw compound spectra
  - Enhanced or background spectra
- Executed chain of custody and sample receipt checklist

The laboratory is only required to submit the above summarized data deliverable as requested. However, at a later date, the project may request the laboratory to provide the associated raw data, instrument printouts, logbook pages, etc. Therefore, the data for this project will be collected and documented in such a manner that will allow the generation of data packages that can be used by an external data auditor to reconstruct the analytical process.

In addition to the hard copy data, a portable document format (PDF) version of the data and a CD containing the data package in PDF format and the EDD will be provided as part of the laboratory deliverable.

Electronic Analytical Record Format

CH2M HILL will obtain EDDs in SEDD version 5.0, compliant with the project specific supplied library. The laboratory will verify that the quality, content, and format comply with the latest SEDD requirements.

Data Assessment Records

Data assessment records include, but are not limited to, data validation reports and corrective action reports.

Worksheet #31, #32, and #33—Assessments and Corrective Actions

Periodic assessments will be performed during the course of the project so that the planned project activities are implemented in accordance with this document. The type, frequency, and responsible parties of planned assessment activities to be performed for the project, as well as, any corrective action measures, are summarized in the table below.

Assessment Type	Responsible Party and Organization	Frequency	Assessment Deliverable	Timeframe of Notification	Person(s) Responsible for Responding to Assessment Findings	Assessment Response Documentation	Timeframe of Response	Person(s) Responsible for Implementing Corrective Actions	Person(s) Responsible for Monitoring Corrective Action Implementation
Field Procedure Assessment and Work Plan Compliance	Glynn Roberts/ CH2M HILL	Weekly	Internal Memorandum	1 business day	Tony Swierczek/ CH2M HILL	Internal Memorandum	1 business day	Glynn Roberts/ CH2M HILL	Chris English/ CH2M HILL
Field Documentation Reviews	Tony Swierczek/ CH2M HILL	Daily	Internal Memorandum	1 business day	Tony Swierczek/ CH2M HILL	Internal Memorandum	1 business day	Glynn Roberts/ CH2M HILL	Chris English/ CH2M HILL
Health and Safety Audit	Carl Woods/ CH2M HILL	Once during field sampling activities	Internal Memorandum	3-5 business days	Carl Woods/ CH2M HILL	Written Audit Report	24 hrs after notification	Chris English/ CH2M HILL	Glynn Roberts/ CH2M HILL
Sample Condition Report	Glynn Roberts/ CH2M HILL	After samples are received at the laboratory	Internal e-mail	24 hrs after sample receipt	Shane Lowe/ CH2M HILL	Internal and External e-mail	24 hrs after notification	Chris English/ CH2M HILL	Shane Lowe/ CH2M HILL
Data Validation	Shane Lowe/ CH2M HILL	After receiving data form laboratory and during data validation	Internal and external e-mail	14 business days	Laboratory QA Manager	Internal and external corrective action reports, updated case narratives, and corrected data submissions	7 business days	Laboratory QA Manager	Doug Scott/ CH2M HILL

Assessment Type	Responsible Party and Organization	Frequency	Assessment Deliverable	Timeframe of Notification	Person(s) Responsible for Responding to Assessment Findings	Assessment Response Documentation	Timeframe of Response	Person(s) Responsible for Implementing Corrective Actions	Person(s) Responsible for Monitoring Corrective Action Implementation
Data Quality Evaluation Report	Shane Lowe/ CH2M HILL	One for each property after all data are validated	Internal and External Report	30 days after completion of validation	Recipients listed in Distribution Memorandum (Worksheet #3)	Internal and external responses to comments and applicable report revision	7-10 business days	Shane Lowe/ CH2M HILL	Doug Scott/ CH2M HILL
Internal Project Reporting Reviews	Chris English/ CH2M HILL	Once per report and/or per report version	Internal Report Comments	7-10 business days	Chris English/ CH2M HILL	Internal and external responses to comments and applicable report revision	7-10 business days	Varies dependent upon the expertise required by the CH2M HILL senior reviewers	Anthony Swierczek/ CH2M HILL

Worksheet #34—Data Verification and Validation Inputs

To confirm that scientifically sound data of known and documented quality are used in making project decisions. This worksheet establishes the procedures that will be followed to verify and validate project data including, but are not limited to, sampling documents and analytical data packages.

Item	Description	Verification (completeness)	Validation (conformance to specifications)
Planning Documents/Records			
1	Approved QAPP	X	
2	Contract	X	
3	Field SOPs	X	
4	Laboratory SOPs	X	
Field Records			
5	Field logbooks	X	X
6	Equipment calibration records	X	X
7	Chain-of-custody forms	X	X
8	Sampling diagrams/surveys	X	X
9	Drilling logs	X	X
10	Geophysics reports	X	X
11	Relevant correspondence	X	X
12	Change orders/deviations	X	X
13	Field audit reports	X	X
14	Field corrective action reports	X	X
Analytical Data Package			
15	Cover sheet (laboratory identifying information)	X	X
16	Case narrative	X	X
17	Internal laboratory chain-of-custody	X	X
18	Sample receipt records	X	X
19	Sample chronology (dates and times of receipt, preparation, and analysis)	X	X
20	Communication records	X	X
21	DL/LOD/LOQ establishment and verification	X	X
22	Instrument calibration records	X	X
23	Definition of laboratory qualifiers	X	X
24	Results reporting forms	X	X
25	QC sample results	X	X
26	Corrective action reports	X	X
27	EDD	X	X

Worksheet #35—Data Verification Procedures

Data verification is a completeness check to confirm that all required activities were conducted, all specified records are present, and the contents of the records are complete. It applies to both field and laboratory records.

Verification Input	Description	Person(s) Responsible for Verification
Chain-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody forms will be initialed by the reviewer, a copy of the chain-of-custody retained in the project file, and the original and remaining copies taped inside the cooler for shipment.	Glynn Roberts/CH2M HILL
Field Notebooks	Field notes will be reviewed internally at the end of each working day and placed in the project file.	Glynn Roberts/CH2M HILL
Field SOPs	Verify that the sampling SOPs were followed.	Glynn Roberts/CH2M HILL
Onsite Screening (such as photoionization readings)	Verify that the field data meets QAPP requirements for completeness and accuracy based on field calibration records.	Glynn Roberts /CH2M HILL
Field Audit Reports and Corrective Actions	Verify that applicable field audits and Health and Safety meetings were completed and that all required corrective action were defined, implemented and effective.	Glynn Roberts /CH2M HILL Chris English/CH2M HILL
Analytical SOPs	Verify that the analytical SOPs were followed.	Laboratory QA Officer/ASL Laboratory QA Officer/Empirical Shane Lowe/CH2M HILL
Laboratory Data	Laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. Received data packages will be validated internally by the CH2M HILL project chemist.	Laboratory QA Officer/ASL Laboratory QA Officer/Empirical Shane Lowe/CH2M HILL
Method QC Results	Verify that the required QC samples were run and met required limits.	Laboratory QA Officer/ASL Laboratory QA Officer/Empirical Shane Lowe/CH2M HILL
Field QC Sample Results	Verify that the required field QC samples were run and met required limits.	Laboratory QA Officer/ASL Laboratory QA Officer/Empirical Shane Lowe/CH2M HILL
Quantification Limits	Verify that the sample results met the project quantification limit specified in the QAPP.	Shane Lowe/CH2M HILL
Laboratory Corrective Actions	Verify that applicable laboratory corrective actions were defined, implemented and effective.	Laboratory QA Officer/ASL Laboratory QA Officer/Empirical Shane Lowe/CH2M HILL
Project Reports	Project reports will undergo a QA review by CH2M HILL senior staff with applicable expertise dependent upon the content of the report.	Various/CH2M HILL

Worksheet #36—Data Validation Procedures

The objective of the data validation is to assess the performance associated with the analysis in order to determine the quality of the data, which will be accomplished by evaluating whether the collected data comply with the pre-defined project requirements (including method, procedural, or contractual requirements) and by comparing the collected data with criteria established based on the project DQOs.

All types of data, including screening data and definitive data, are relevant to the usability assessment. The following sections focus on the data review requirements for definitive data only.

TABLE 36-1
Validation Summary
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Matrix	Analytical Group	Validation Criteria	Data Validator
Groundwater	VOCs	Defined in WS#28, Tables 36-3 through 36-5 and below	Shane Lowe/CH2M HILL
Vapor	VOCs	Defined in WS#28, Tables 36-3 through 36-5 and below	Shane Lowe/CH2M HILL

Data Review Requirements for Definitive Data

Scientifically sound data of known and documented quality that meet the DQOs are essential to the decision making process. Data will be examined and evaluated to varying levels of detail and specificity by a variety of personnel who have different responsibilities within the data management process. Data assessment includes verification, review, validation, evaluation and usability assessment. The data review process will be documented to facilitate efficient and accurate assessment of data quality and usability. The overall usability of the data is indicated with appropriate qualifiers.

Laboratory Requirements

The analytical data package must contain adequate information and be presented in a clear and concise manner. The laboratory data package should be organized such that the analytical results are reported on a per analytical batch basis, unless otherwise specified. A reviewer should be able to determine the PARCCS of the data, based on the information contained in the data package. Additional information may be required, depending on the detail of data review performed.

A schedule should be established so that data packages (that is, sample delivery groups) are provided in a timely manner to CH2M HILL for data review, validation, assessment, and use. This includes identifying the anticipated number of these data packages to be generated for the project.

Laboratory Data Reporting Requirements

The following requirements should be met for reporting:

- LODs and sample results should be reported to one decimal place more than the corresponding LOQ, unless the appropriate number of significant figures for the measurement dictates otherwise.
- Samples will be analyzed undiluted if possible. Nondetects will be reported to the LODs. LODs and LOQs for minority chemicals in highly-contaminated samples may have to be adjusted because of dilutions.

Manual Integrations

Manual integrations are an integral part of the chromatographic analysis process and will be done only as a corrective action measures. Examples of instances where manual integration would be warranted include, but are not limited to, co-eluting compounds resulting in poor-peak resolution, a misidentified peak, an incorrect RT, or a problematic baseline.

When manual integrations are used, the following procedures will be implemented to document the event and for consistency in performing the manual integration:

- An LSOP will be followed for manual integrations. This SOP will specify the following: (1) when automated integrations by the instrument are likely to be unreliable, (2) what constitutes an unacceptable automated integration, (3) how the problems should be resolved by the analyst, and (4) the procedures for the analyst to follow in documenting any required manual integrations.
- Raw data records will include a complete audit trail for those manipulations, including the following: (1) results of both the automated and manual integrations, (2) notation of the cause and justification for performing the manual integrations, (3) date, and (4) signature or initials of person performing the manual operations.
- All manual integrations must be reviewed and approved by the section supervisor and/or the QA officer.
- All manual integrations must be identified in the case narrative.

Laboratory Data Review Requirements

All definitive data will be reviewed first by the laboratory analyst and then by the laboratory supervisor of the respective analytical section using the same criteria before they are submitted to CH2M HILL. This internal data review process, which is multi-tiered, should include all aspects of data generation, reduction, and QC assessment. Elements for review or verification at each level must include, but are not limited to, the following:

- Sample receipt procedures and conditions
- Sample preparation
- Appropriate LSOPs and methodologies
- Accuracy and completeness of analytical results
- Correct interpretation of all raw data, including all manual integrations
- Appropriate application of QC samples and compliance with established control limits
- Verification of data transfers
- Documentation completeness
- Accuracy and completeness of data deliverables (hard copy and electronic)

Laboratory Data Evaluation

The calibration, QC, corrective actions, and flagging requirements for definitive data are provided in Worksheet #28 (Analytical Quality Control and Corrective Action). Data qualifiers should be applied by the laboratory as part of their internal validation activities. The allowable data qualifiers for definitive data are *Q, E, J, B*, *and U.* The definitions of the data qualifiers are provided in the Table 36-2. Flagging criteria apply when acceptance criteria are not met and corrective actions were not successful or not performed. The data qualifiers must be reviewed by the supervisor of the respective analytical sections.

The laboratory QA section should perform a 100 percent review of 10 percent of the completed data packages. The laboratory project representative should complete a final review on all the completed data packages.

CH2M HILL project chemist or designee will subsequently evaluate the flags applied by the laboratory as part of their data review and usability assessment activities. The flags may be accepted, modified, or rejected. For all data qualifiers that are changed, clear justification will be provided. All Q-flagged data will be evaluated and either accepted without qualification, accepted with qualification, or rejected.

TABLE 36-2
Laboratory Data Qualifiers
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Qualifier	Description
Q	This indicates that one or more QC criteria fail. Data must be carefully assessed by CH2M HILL (or project team) with respect to the project-specific requirements and evaluated for usability. Subsequent assessment by DoD may result in rejection of data.
J	The analyte was positively identified; the quantitation is an estimation because of discrepancies in meeting certain analyte-specific QC criteria.
B	The analyte was found in an associated blank above one half the LOQ, as well as in the sample.
U	The analyte was analyzed for but not detected.
E	Exceeds calibration range of the instrument.

CH2M HILL Requirements

CH2M HILL has overall responsibility for data quality and may be assisted in its review by external organizations. Regardless of who performs the data review, the individual(s) should possess the disciplinary expertise, experience, and theoretical knowledge to perform the task, and a complete understanding of the intended use of the data and the relationship of the QC results to the usability of the data.

Data Verification Guidelines

CH2M HILL Project Chemist will review the data verification performed by the laboratory for completeness and accuracy. Data verification may be done electronically or manually, or by a combination of both. The verification process includes, but is not limited to the following:

- Sampling documentation (such as the chain-of-custody form)
- Preservation summary and holding times
- Presence of all analyses and analytes requested
- Use of required sample preparation and analysis procedures
- LODs and LOQs
- Correctness of concentration units
- Case narrative

Data Validation Guidelines

Data validation extends data verification and is used to confirm that the requirements for a specific intended use are fulfilled. Data validation is the systematic process of evaluating the compliance of the data with the pre-defined requirements of the project (including method, procedural, or contractual requirements) and compliance of the data against criteria based on the quality objectives documented in this document. The purpose of data validation is to assess the performance associated with the analysis in order to determine the quality of the data. Data validation includes a determination, to the extent possible, of the reasons for any failure to meet performance requirements, and an evaluation of the impact of such failures on the usability of the data. The project chemist may add or delete data qualifier flags during validation.

Validation will be performed on an analytical batch basis by assessing QC samples and associated field sample results. Data validation guidelines have been developed in accordance with the method requirements, professional judgment and general DoD requirements. The following information will be reviewed as part of a Level-III type summary data validation:

- Chain-of-custody documentation
- Holding time
- QC sample frequencies

- Method blanks
- LCS
- Surrogate spikes
- MS/MSD
- Initial and continuing calibration information
- Internal standards
- Tuning criteria
- FD precision
- Case narrative review and other method-specific criteria

Raw Data Review

Data review can involve an in-depth review of the raw data to verify accuracy followed by analysis and interpretation of the data in the context of the project objectives and end-use as part of the usability assessment. The review may include but is not limited to the following:

- Method-specific instrument calibration and QC parameters
- Raw data and chromatograms
- System performance
- Proper integration (if applicable)
- Spectral matches, and/or RTs to verify analyte identification (where applicable)
- Random check of calculations
- Interference problems or system performance problems
- Estimated results (such as F-qualifiers)
- Resolution by the laboratory of any identified problems, as necessary

ADR.net will be used to perform the comparisons against the limits for elements of QC that are available in the laboratory electronic deliverables. Calibration, internal standards and tuning criteria will be reviewed manually in the laboratory data packages. The process will include data flagging for issues related to method blanks, equipment blanks, trip blanks, ambient blanks, LCSs, MS/MSD samples, FDs, surrogate recoveries, holding time, and reconciliation of dilutions and re-extractions. All of the elements of QC, their limits, and the logic for applying flags will be incorporated in the electronic database. Data flags, as well as the reason for each flag, will be entered into an electronic database and made available to the data users. A final flag is applied to the data by the data validator/chemist after evaluating all flags entered into the database and selecting the most conservative flags.

Data Assessment and Interpretation

This phase of the data validation process (assessment) may include but is not limited to the review of the following:

- All Q-flagged data and final determination of its usability
- All B-flagged data and final determination of its usability
- Laboratory and field blank contamination and parallel contamination in samples
- Duplicate and replicate sample analyses
- All M-flagged data
- Potential LCS failure where marginal exceedances criteria may apply
- Impact of multiple data issues on the final analytical results
- Deficiencies identified during data verification and assessment of their impact on the sample results
- Incorporation of site-specific factors and assessment of their impact on the data
- Assessment of data usability and assignment of final data qualifiers listed in Table 36-3, as necessary
- Discussion of completeness, representativeness, and comparability

Data flags, as well as the reason for each flag, will be entered into an electronic database and made available to the data users. A final flag is applied to the data by the data validator/chemist after evaluating all flags entered into the database and selecting the most conservative flags.

ADR.net will be used to perform the comparisons against the limits for elements of QC that are available in the laboratory electronic deliverables. Calibration, internal standards and tuning criteria will be reviewed manually in the laboratory data packages. The process will include data flagging for issues related to method blanks, equipment blanks, trip blanks, ambient blanks, LCSs, MS/MSD samples, FDs, surrogate recoveries, holding time, and reconciliation of dilutions and re-extractions. All of the elements of QC, their limits, and the logic for applying flags will be incorporated in the electronic database.

A data validation report will be prepared to summarize the findings and their impact on the overall data usability. This may be incorporated into the final usability assessment.

Method Blank Evaluation Guidance

For method blanks, the source of contamination should be investigated. If one-half the LOQ is exceeded, the laboratory should evaluate whether reprocessing of the samples is necessary using the following criteria: (1) the method blank contamination exceeds a concentration greater than 1/10 of the measured concentration of any sample in the associated preparation batch; or (2) there is evidence indicating that the blank contamination otherwise affects the sample results. Except when the sample analysis resulted in a nondetect, all samples associated with method blank contamination and meeting these criteria must be reprocessed in a subsequent preparation batch. If no sample volume remains for reprocessing, the results will be reported with a B-flag, along with any other appropriate data qualifier. If an analyte is found only in the method blank, but not in any batch samples, no flagging is necessary. Method blank contamination must be addressed in the case narrative.

CH2M HILL project chemist will evaluate laboratory B-qualified data such as method blanks, as well as other field blanks based on the concentration of the analyte in the samples in relation to the concentration in the blank. The B-flag may be removed and not used if the analyte concentrations in the samples are much higher (≥ 5 times) than in the blank (≥ 10 times in case of common laboratory contaminants). Any blank contamination that may impact data usability must be discussed in conjunction with project-specific goals. When a data set contains low-level detects in field samples and has associated field or laboratory blanks that have detects at similar concentrations, this suggests that the low-level detects in these field samples may be artifacts because of either field or laboratory practices. A sample detect that is ≤ 5 times the blank contamination (≤ 10 times for common laboratory contaminants) may be considered a nondetect and flagged "U" at the detected concentration.

Duplicate Evaluation Guidance

QC measures for precision include FDs, field replicates, laboratory duplicates, MSDs, analytical replicates, and surrogates. These measures will be evaluated by the laboratory and qualified according to applicable procedures, with the exception of the FDs.

Specifically, FDs should be sent to the laboratory as blind samples and should be given unique sample identification numbers. These sample results can be used to assess field sampling precision, laboratory precision, and, potentially, the representativeness of the matrix sampled. Flagging of results associated with FDs should be assigned such that the level of uncertainty required, as provided by the project-specific objectives, is taken into account.

Poor overall precision may be the result of one or more of the following: field instrument variation, analytical measurement variation, poor sampling technique, sample transport problems, or spatial variation (heterogeneous sample matrices). To identify the cause of imprecision, the project team should evaluate the field sampling design rationale and sampling techniques, and review both field and analytical duplicate sample results. If poor precision is indicated in both the field and analytical duplicates, then the laboratory may be the source of error. If poor precision is limited to the FD results, then the sampling technique, field instrument variation, sample transport, and/or spatial variability may be the source of error. If data validation reports indicate that analytical imprecision exists for a particular data set or sample delivery group, then the impact of that imprecision on usability must be discussed in the report.

Flagging Conventions

The allowable final data qualifiers for definitive data and the hierarchy of data qualifiers, listed in order of the most severe through the least severe, are R, J, UJ, and U. Their definitions are summarized in Table 36-3.

TABLE 36-3
Usability Assessment Data Qualifiers
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Qualifier	Description
R	The data are rejected because of deficiencies in meeting QC criteria and may not be used for decision making.
J	The analyte was positively identified; the quantitation is an estimation because of discrepancies in meeting certain analyte-specific QC criteria or the analyte was positively identified but the associated concentration is an estimation above the DL and below the LOQ.
UJ	The analyte was not detected; however, the result is estimated because of discrepancies in meeting certain analyte-specific QC criteria.
U	The analyte was analyzed for, but not detected or is qualified as nondetect because of blank contamination.

Table 36-4 presents the specific guidelines for applying these data usability qualifiers and includes additional information that is not included in the table as published by the DoD QSM Version 4.2, but can be used to help define additional general flagging criteria applied (in some cases based on professional judgment). Table 36-5 presents the final data reporting flag conventions to be used in compliance with the DoD QSM version 4.2.

TABLE 36-4
General Data Qualifying Conventions
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Requirement	Criteria	Flag	Flag Applied To
Holding Time	Time exceeded for extraction or analysis by a factor of 2 or more	J for the positive results; R or UJ for nondetects*	All analytes in the sample
Sample Preservation	Sample not preserved (If sample preservation was not done in the field but was performed at the laboratory upon sample receipt, no flagging is required, metals only)	J positive results; R or UJ for nondetects*	Sample
	Temperature out of control	J for positive results; UJ for nondetects* R based on professional judgment	Sample
Sample Integrity (SW8260)	Bubbles in VOA vial greater than 4mm (pea-size) used for analysis	J for the positive results; UJ for nondetects R based on professional judgment	Sample
Instrument Tuning	Mass assignment error or Ion abundance method-specific criteria not met	R for all results, if critical ions involved, use judgment otherwise	All associated samples in analytical batch
Initial Calibration	All analytes must be within method-specified criteria %RSD greater than 15% and no calibration curve used or linear calibration curve used R less than 0.990 or R2 less than 0.995 (SW8260) %RSD >30% (TO-15 SIM)	J for positive results; UJ for nondetects, R based on professional judgment	All associated samples in analytical batch

TABLE 36-4
General Data Qualifying Conventions
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Requirement	Criteria	Flag	Flag Applied To
Second Source Check or Continuing Calibration	All analytes must be within method-specified criteria %RSD greater than 20% (SW8260); %RSD greater than 30% (TO-15 SIM)	High Bias: J for positive results, no flag for nondetects Low Bias: J for positive results, UJ for nondetects J positive/R all nondetects greater than twice the control criteria	All associated samples in analytical batch
LCS	Organics: %R greater than UCL %R less than LCL and greater than 10% %R less than LCL and less than 10%	J for the positive results; J for the positive results; UJ for the nondetects J for the positive results; R for the nondetects	The specific analyte(s) in all samples in the associated analytical batch
Internal Standards	Area greater than UCL Area less than LCL Sample is re-extracted and reanalyzed and recovery outside of criteria is confirmed as a matrix effect	J for positive results J for the positive results; UJ for the nondetects If area is to low based on professional judgment, UJ or R nondetects	Sample
Surrogate Spikes	%R greater than UCL %R less than LCL and greater than 10% %R less than 10% Excessive dilution	J for positive results J for positive results; UJ for nondetects J for positive results; R for nondetects No flag required	Sample
Organic Blanks (Method, Equipment, Ambient or Trip)	Analyte(s) detected greater than 1/2 LOQ (use the blank of the highest concentration)	U for positive sample results ≤ 5x highest blank concentration (10x for common laboratory contaminants)	All samples in preparation, field or analytical batch, whichever applies
Field duplicates or laboratory duplicates	Both sample results greater than 5 times LOQ and RPD greater than UCL or One or both samples less than 5 times LOQ and a difference between results of ±2 times LOQ for water and air	J for the positive results J for the positive results UJ for the nondetects	The specific analyte(s) in all samples collected on the same sampling date Note: No flagging is required for RPDs based on J-flagged results
MS/MSD	%R greater than UCL %R less than LCL and >10% %R less than 10% or MS/MSD RPD greater than CL; Sample concentration greater than 4x spike concentration; Excessive dilution*	J for positive results J for positive results; UJ for nondetects J for positive results; R for nondetects J for positive results No flag required	The specific analyte(s) in the parent sample
RT Window	Analyte within established window	R for all results	Sample
Canister Pressure (not applicable to Grab Samples)	If Initial pressure less than 28 inches Hg	J for positive results; UJ for nondetects	Sample
	If Final pressure greater than 20 inches Hg: Slight change (20-27 inches) No change in pressure	J for positive results; UJ for nondetects Apply R to all data.	

TABLE 36-4
General Data Qualifying Conventions
UFP-QAPP—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

QC Requirement	Criteria	Flag	Flag Applied To
	If less than 2 inches Hg—Sampling time cannot be verified. Qualify data as estimated.	Apply J to detects and UJ to nondetects	
Canister/Flow controller Certification (Individual)	Analyte(s) detected greater than DL	U for positive sample results ≤ 5x blank concentration (10x for common laboratory contaminants)	Sample

* = Based on analyte-specific review
CL = control limit
LCL = lower confidence limit
LCS = laboratory control sample
MS = matrix spike
MSD = matrix spike duplicate
ND = not detected
QC = quality control
LOQ = limit of quantitation
UCL = upper confidence limit
VOA = volatile organic analysis

TABLE 36-5
Data Qualifying Conventions—Quantitation
Remedial Investigation of Operable Unit 2 at the St. Louis Ordnance Plant, Former Hanley Area, St. Louis, MO

Criteria	Flag
< DL	U, UJ at the LOD
≥ DL < LOQ	J
≥ LOQ	As needed
≥ high standard/linear range	J

Examples:
DL = 2, LOD = 4, LOQ = 15, sample is undiluted.
Example #1: Analytical result: not detected; reported result: <4U.
Example #2: Analytical result: 3; reported result: 3J.
Example #3: Analytical result: 10; reported result: 10J.
Sample #4: Analytical result: 15; reported result: 15.

Worksheet #37—Data Usability Assessment

The data usability assessment is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment is used to determine whether the project execution and resulting data meet the project DQOs. Both the sampling and analytical activities must be considered, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data.

The following sections summarize the processes to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision making for the project, and describe how data quality issues will be addressed and how limitations of the use of the data will be handled.

Summary of Usability Assessment Processes

Data gaps may be present if (1) a sample is not collected, (2) a sample is not analyzed for the requested parameters, or (3) the data are determined to be unusable. The need for further investigation will be determined on a case-by-case basis, depending on whether data can be extrapolated from adjacent sample locations, and whether the data are needed based on the results from adjacent sample locations.

The CH2M HILL project chemist and the laboratory will confirm that the collected data meet the LODs, LOQs, and laboratory QC limits specified in this document. During the data validation assessment, nonconformances will be documented, and data will be qualified accordingly. The CH2M HILL project chemist will determine whether the data are usable based on the requirements specified in this document.

All data as qualified by the CH2M HILL project chemist are considered useable, with the exception of rejected data. Estimated and/or biased results are considered usable. Outliers, if present, can be addressed on a case-by-case basis. There is no generic formula for determining whether a result is an outlier. Potential outliers will be referred to a statistician and/or senior consultant, who will determine which formulas are appropriate for classifying data points in a statistically appropriate and defendable manner.

Evaluative Procedures to Assess Project-Specific Overall Measurement Error

Overall measurement error is normally associated with both sampling design and quality and quantitative measures performed in both the field and laboratory. In-depth assessment will be performed during the data review and validation processes to assess conformance with the field SOPs, LSOPs, and objectives of this document. Qualifiers will be used to indicate overall usability of the data.

Personnel Responsible for Performing Usability Assessment

Doug Scott/CH2M HILL Project Chemist
Shane Lowe/CH2M HILL Project Chemist
Chris English/CH2M HILL PM
Anthony Swierczek/CH2M HILL QC Systems Manager
Loren Lund/CH2M HILL Senior Technical Consultant

Usability Assessment Documentation

All the results will be assembled and statistically reported for an overall quality assessment in a data validation report, which will be provided as an appendix to the technical memorandum. The data validation report will identify precision and accuracy exceedances with respect to the laboratory performance for each batch of samples, as well as comparability of field and laboratory duplicates. Discussion will cover PARCC criteria as described in the following subsections.

Precision

Laboratory precision is measured by the variability associated with duplicate (two) or replicate (more than two) analyses. One type of sample that can be used to assess laboratory precision is the LCS. Multiple LCS analyses over the duration of the project can be used to evaluate the overall laboratory precision for the project. In this case, the comparison is not between a sample and a duplicate sample analyzed in the same batch, but between LCSs analyzed in multiple batches.

Total precision is the measurement of the variability associated with the entire sampling and analytical process. The required levels of precision for each method, matrix, and analyte are provided in Worksheet #15 (*Project Action Limits and Laboratory Specific Detection/Quantitation Limits*). Precision is determined by analysis of duplicate field samples, laboratory duplicates, and/or MSDs. Field duplicate samples, laboratory duplicate, and MSD samples should be analyzed to assess field and laboratory precision at a frequency as described in Worksheet #20 (*Field QC Summary*). For duplicate sample results, the precision is evaluated using the RPD. For replicate results, the precision is measured using the RSD. The formula for the calculation of RPD and RSD are provided below.

If calculated from duplicate measurements:

$$RPD = 100\% \times \frac{(C_1 - C_2)}{(C_1 + C_2) \times \frac{1}{2}} \quad (1)$$

Where:

RPD = relative percent difference

C_1 = larger of the two observed values

C_2 = smaller of the two observed values

- If calculated from three or more replicates, use RSD rather than RPD:

$$RSD = 100\% \times (s / \bar{y}) \quad (2)$$

Where:

RSD = relative standard deviation
s = standard deviation

$\bar{y}$ = mean of replicate analyses

Standard deviation, σ, is defined as follows:

$$\sigma = \sum_{i=1}^{n} \sqrt{\frac{(y_i - \bar{y})^2}{n-1}} \quad (3)$$

Where:

σ = standard deviation

y_i = measured value of the i^{th} replicate

$\bar{y}$ = mean of replicate analyses

n = number of replicates

Accuracy

Accuracy reflects the total error associated with a measurement. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within

acceptable limits. Analytical accuracy is measured by comparing the percent recovery (*%R*) of analytes spiked into an LCS or MS to a control limit. For many methods of organic compound analysis, surrogate compound recoveries also are used to assess accuracy and method performance for each sample analyzed.

Both accuracy and precision are calculated for each analytical batch, and the associated sample results are interpreted by considering these specific measurements. The formula for calculation of accuracy is included below as *%R* from pure and sample matrices. Accuracy requirements are listed for each method, matrix, and analyte in Worksheet #15 (*Project Action Limits and Laboratory Specific Detection/Quantitation Limits*).

For measurements where MSs are used:

$$\%R = 100\% \times \left[\frac{S - U}{C_{sa}} \right] \quad (4)$$

Where:

%R = percent recovery
S = measured concentration in spiked aliquot
U = measured concentration in unspiked aliquot
C_{sa} = actual concentration of spike added

For situations where a LCS is used instead of or in addition to MSs:

$$\%R = 100\% \times \left[\frac{C_m}{C_{sm}} \right] \quad (5)$$

Where:

%R = percent recovery
C_m = measured concentration of LCS
C_{sm} = actual concentration of LCS

Representativeness

Representativeness is a qualitative term that refers to the degree in which data accurately and precisely depicts the characteristics of a population, whether referring to the distribution of contaminant within a sample, a sample within a matrix, or the distribution of a contaminant at a site. Representativeness is determined by appropriate program design, with consideration of elements such as sampling locations. Objectives for representativeness are defined for each sampling and analysis task and are a function of the investigative objectives. Assessment of representativeness will be achieved through use of the standard field sampling and analytical procedures. Decisions regarding sample locations process and numbers and the statistical sampling design are documented in Worksheets #10 (*Conceptual Site Model*), #11 (*Project/Data Quality Objectives*), and #17 (*Sampling Design and Rationale*).

Comparability

Comparability is a qualitative indicator of the confidence with which one data set can be compared to another data set. The objective for this QA/QC program is to produce data with the greatest possible degree of comparability. The number of matrices that are sampled and the range of field conditions encountered are considered in determining comparability. Comparability is achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats. Complete field documentation using standardized data collection forms supports the assessment of comparability. Historical comparability can be achieved through consistent use of methods and documentation procedures throughout the project. Assessment of comparability is considered subjective and the results should be interpreted by experienced environmental professionals with a clear knowledge of the PQOs and project decisions.

Completeness

Completeness is a measure of the amount of valid data obtained compared with the amount that was expected to be obtained under correct, normal conditions. It is calculated for the aggregation of data for each analyte measured for any particular sampling event or other defined set of samples (for example, by site) as set out in the DQOs. Valid data are data that are usable in the context of the project goals. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with an R-flag after a usability assessment has been performed. Completeness should not be determined only based on laboratory data qualifiers. The goal for completeness is 95 percent for all samples.

Completeness is calculated as follows for all measurements:

$$\%C = 100\% \times \left[\frac{V}{T}\right] \quad (6)$$

Where:

%C = percent completeness
V = number of measurements judged valid
T = total number of measurements

Sensitivity

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet project-specific objectives. It is important to be able to detect the target analytes at the levels of interest. Sensitivity requirements include the establishment of various limits such as calibration requirements, instrument LODs, and LOQs. The project QA/QC on method requirements has been established to be compliant with the DoD QSM Version 4.2 (DoD 2010). Project-specific LOD and LOQs are established in Worksheet #15 based on project-specific action level objectives.

References

Agency for Toxic Substances and Disease Registry. 2005. *Toxicological Profile for 1,2-Dichloroethane.* August.

CH2M HILL. 2009. *Final Remedial Investigation, St. Louis Ordnance Plant, Former Hanley, St. Louis*, *Missouri*. November.

CH2M HILL. 2010. *Final Feasibility Study Report, St. Louis Ordnance Plant, Former Hanley, St. Louis*, *Missouri*. July.

CH2M HILL. 2011a. *Final Decision Document – Operable Unit 1, St. Louis Ordnance Plant, Former Hanley, St. Louis*, *Missouri*. September.

CH2M HILL. 2011b. *Vapor Intrusion Assessment Work Plan Addendum—Revision 1, Former Hanley Area, St. Louis Ordnance Plant, St. Louis, Missouri.* December.

CH2M HILL. 2011c. *Vapor Intrusion Assessment at Private Property PP-1, St. Louis, Missouri.* May.

CH2M HILL. 2011d. *Vapor Intrusion Assessment at Private Property PP-17, St. Louis, Missouri*. May.

CH2M HILL. 2011e. *Final Remedial Design/Remedial Action Work Plan, St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri*. September.

CH2M HILL. 2012a. *Final Interim Remedial Action Completion Report – Operable Unit 1, St. Louis Ordnance Plant, St. Louis, Missouri*. September.

CH2M HILL. 2012b. *Investigation Approach for Day Care Center at 4725 Goodfellow Boulevard, St. Louis, Missouri.* October 22.

CH2M HILL. 2012c. *Final OU-1 Long Term Management Plan/Land Use Control Implementation Plan*. September.

CH2M HILL. 2012d. *December 2011 Vapor Intrusion Assessment at Private Property PP-1, St. Louis, Missouri.* April 20.

CH2M HILL. 2012e. *December 2011* V*apor Intrusion Assessment at Private Property 17, St. Louis, Missouri*. April 20.

CH2M HILL. 2012f. *February 2012 Vapor Intrusion Assessment at Private Property PP-2, St. Louis, Missouri*. May 10.

CH2M HILL. 2012g. *February 2012 Vapor Intrusion Assessment at Private Property 3, St. Louis, Missouri.* May 10.

CH2M HILL. 2012h. *June 2012 Vapor Intrusion Assessment at Private Property PP-1, St. Louis, Missouri.* September 28.

CH2M HILL. 2012i. *July 2012 Groundwater Monitoring Report—Operable Unit 1, St. Louis Ordnance Plant, Former Hanley Area, St. Louis*, *Missouri.* September.

Department of Defense (DoD). 2010. *DoD Quality Systems Manual for Environmental Laboratories*. Version 4.2. October.

Geological Society Working Group. 1995. "The Description and Classification of Weathered Rocks for Engineering Purposes." *Quarterly Journal of Engineering Geology*. Vol. 28. pp. 207-242.

Miller, D. E., et al. 1974. *Water Resources of the St. Louis Area, Missouri.* Missouri Geological Survey and Water Resources WR 30.

National Climatic Data Center. 1998. *Climatic Wind Data for the United States.* http://www5.ncdc.noaa.gov/documentlibrary/pdf/wind1996.pdf.

National Oceanic and Atmospheric Administration. 2007. *The Climatology of St. Louis and the Bi-State Area.* http://www.crh.noaa.gov/lsx/climate/cli-sum1.php.Pangea, Inc. 2003. *Phase I Environmental Site Assessment. Former St. Louis Ordnance Plant, 6400 Stratford Ave., St. Louis, Missouri*. September.

St. Louis Planning and Urban Design Agency. 2009. St. Louis Strategic Land Use Plan. http://stlcin.missouri.org/landuse/map.cfm?globalpointx=886571.442429&globalpointy=1042392.7517&extent=2750.

TapanAm Associates, Inc. 2001. Preliminary *Assessment/Site Inspection Report for Former St. Louis Ordnance Plant, St. Louis County. Missouri.* October.

U.S. Army Corps of Engineers (USACE). 2005. *Technical Memorandum—Final Hanley Area Phase I Remedial Investigation, Former St. Louis Ordnance Plant, St. Louis*. Missouri. May.

USACE. 2007. *Final Supplemental Soil and Groundwater Phase II Remedial Investigation Technical Memorandum, Hanley Area, Former St. Louis Ordnance Plant, St. Louis, Missouri*. June 25.

U.S. Army Toxic and Hazardous Materials Agency—Battelle Columbus Laboratories. 1991. Survey of Hazardous/Chemical Area No. 2 of the Former St. Louis Ordnance Plant, Volumes I and II, Final Report. June.

U.S. Environmental Protection Agency (USEPA). 1988a. *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy*. Office of Ground-Water Protection (WH-550G). June.

USEPA. 1988b. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final. EPA/540/G-89/004.

USEPA. 1989. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)*. USEPA/540/1-89/002.

USEPA. 1999. *Compendium Method TO-15 Determination Of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS).* EPA/625/R-96/010b. January.

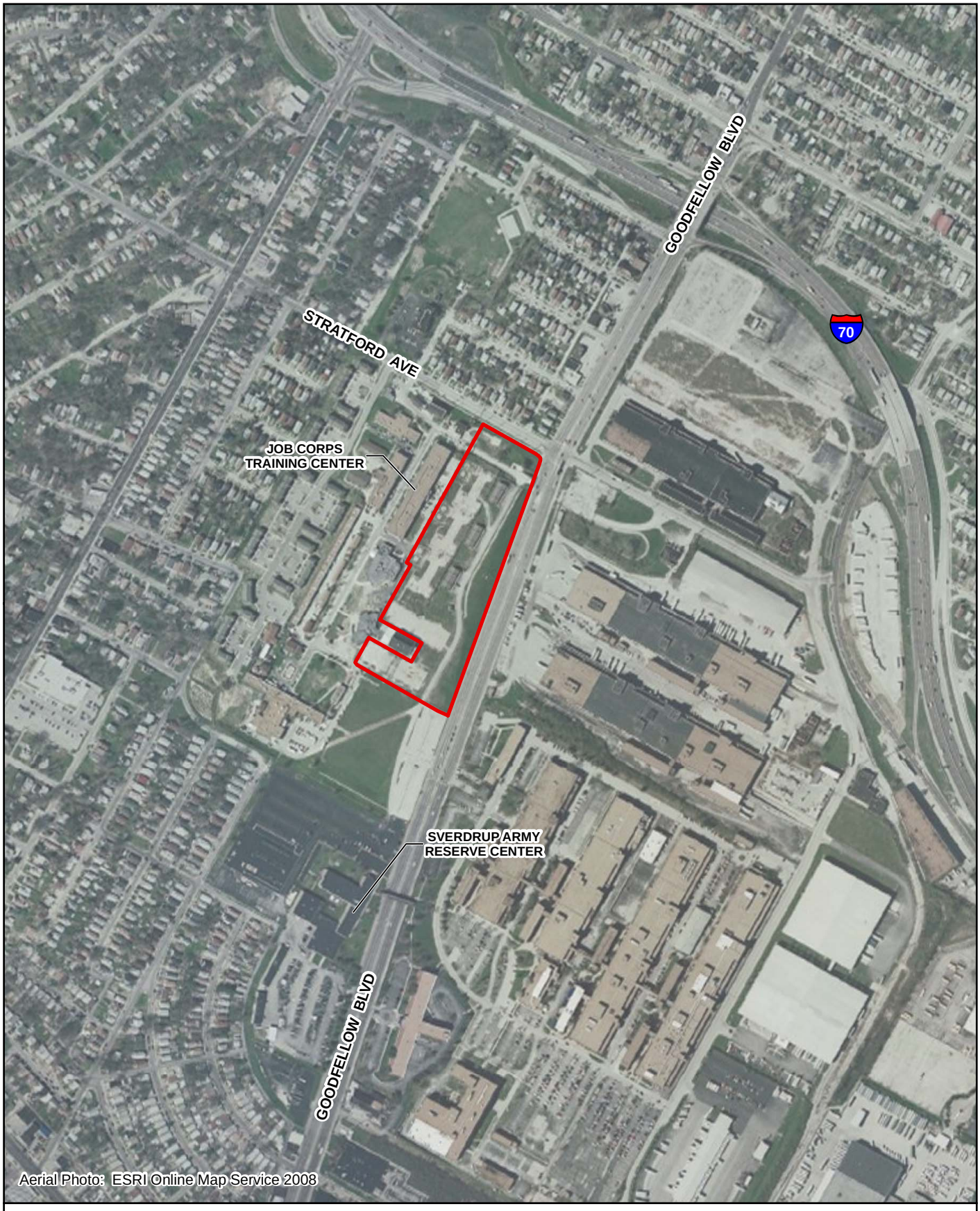
USEPA. 2002. *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). Federal Register,* Vol. 67, No. 230. pp. 71169–72.

USEPA. 2004. *Risk Assessment Guidance for Superfund, Volume I: HHEM (Part E, Supplemental Guidance for Dermal Risk Assessment).* EPA/540/R-99/005.

USEPA. 2008. *Revised Superfund Removal Action Levels.* Memorandum from OSWER Office of Emergency Management to Regional Superfund Division Directors and Regional Removal Managers. September 17.

USEPA. 2009. *Risk Assessment for Superfund, Volume 1: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).* EPA-540-R-070-002.

Figures



N

0 300 600

Feet

LEGEND

Site Boundary

FIGURE 1
SITE LOCATION MAP
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

CH2MHILL

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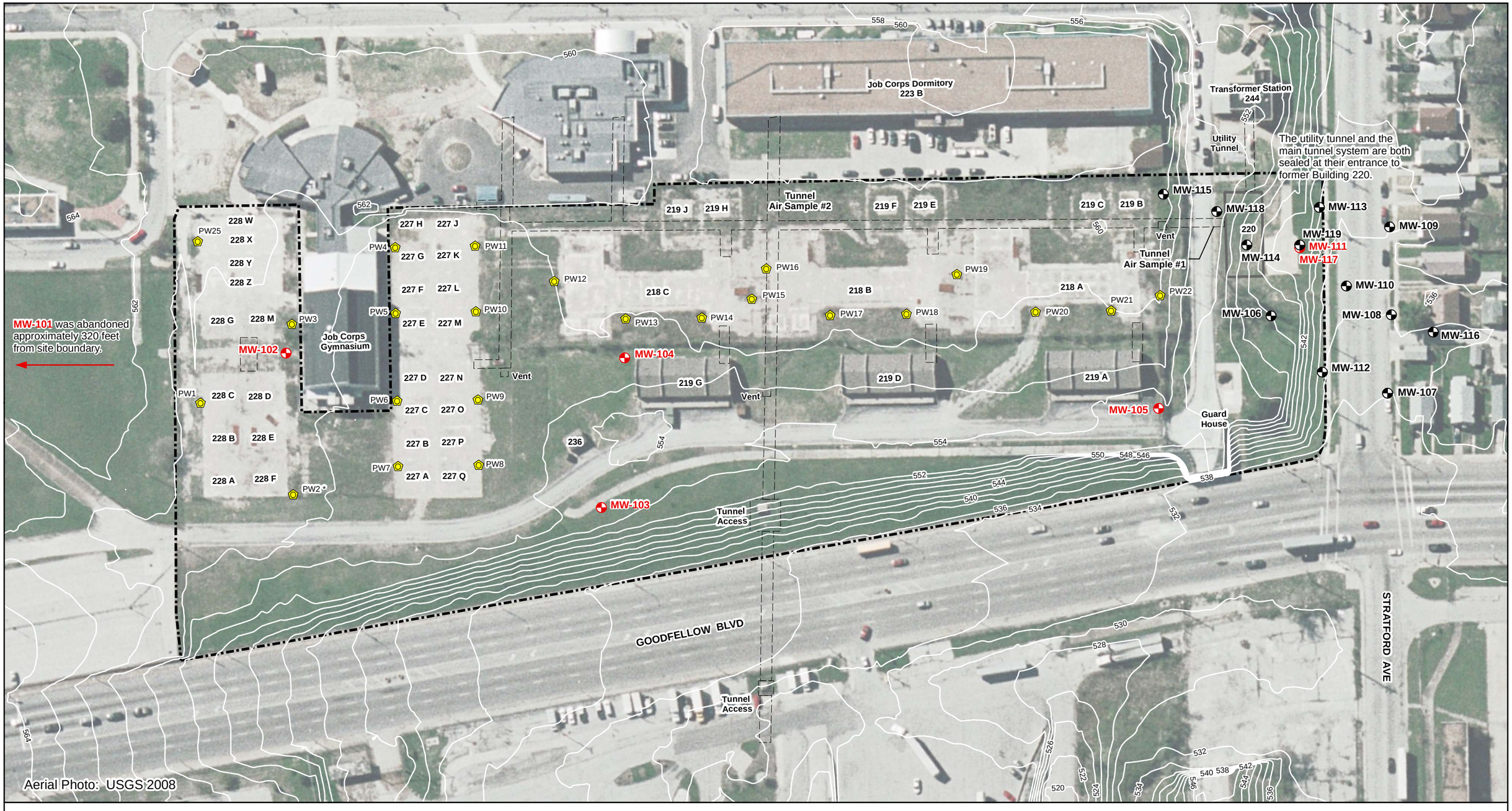


0 50 100 Feet

LEGEND

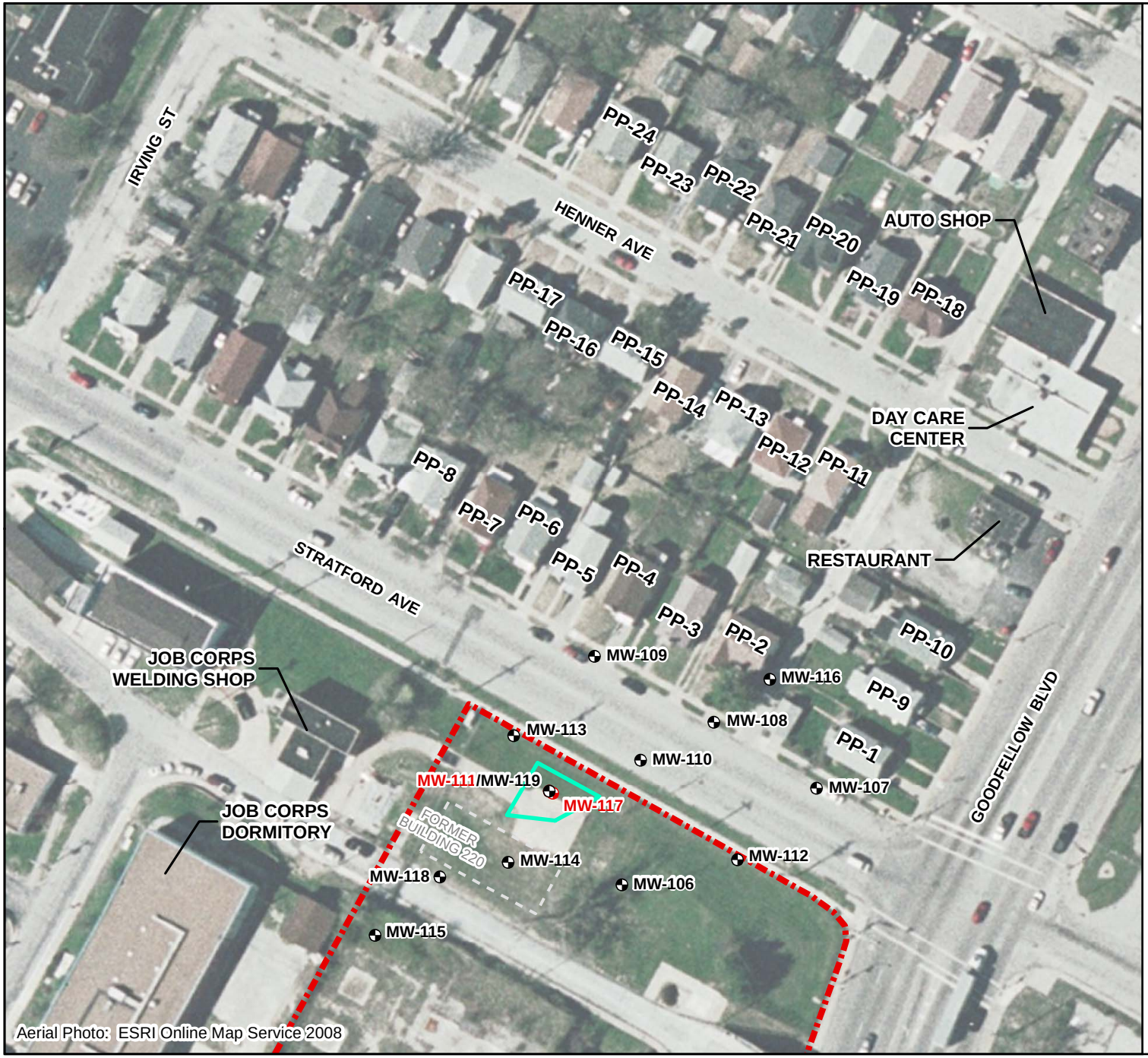
- Monitoring Well
- Monitoring Well Abandoned in 2012
- Backfilled Powder Well
- Elevation Contour (2-foot interval)
- Site Boundary
- 220 Former Building
- Tunnel System

NOTE:
1. Elevation contours were obtained from St. Louis Metropolitan Sewer District
2. * - PW2 could not be located during 2012 field reconaissance and could not be remediated or backfilled.

FIGURE 2
CURRENT SITE FEATURES
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

CH2MHILL

RDD \\BALDUR\PROJ\SLOP_349765\MAPFILES\UFP_QAPP\FIG2_SITE_FEATURES_QAPP.MXD MSCHROCK 7/18/2013 10:34:12 PM



LEGEND

- Site Boundary
- Soil Mixing Treatment Area
- Former Building
- Existing Monitoring Well
- Abandoned Monitoring Well

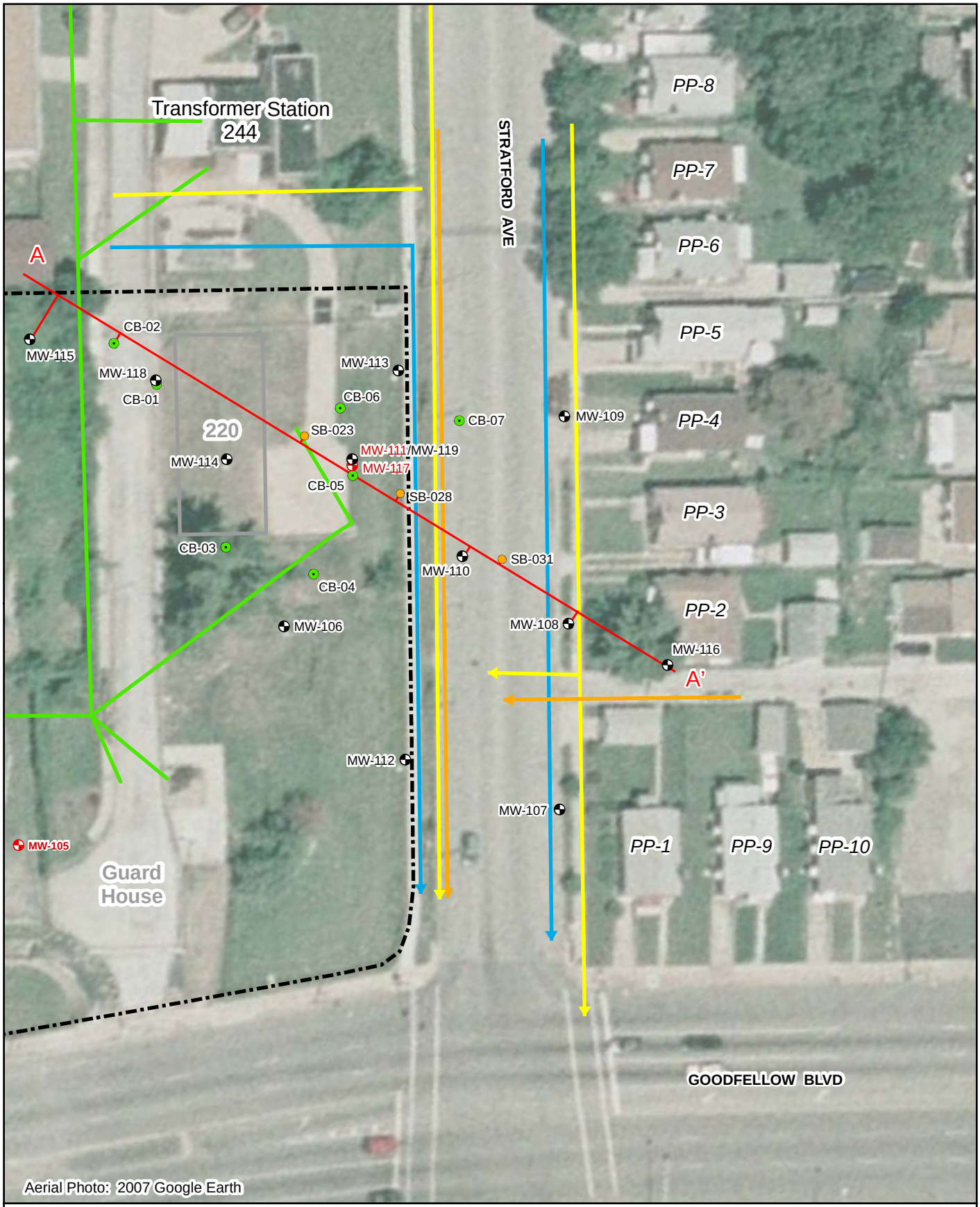
N

0 50 100 Feet

FIGURE 3
PROPERTIES ADJACENT TO FORMER HANLEY AREA
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

RDD \\BALDUR\PROJ\SLOP_349765\MAPFILES\UFP_QAPP\FIG3_ADJ_PROPERTIES_QAPP.MXD MSCHROCK 11/16/2012 2:03:55 AM

CH2MHILL



LEGEND

- Soil Boring (2005/2006)
- Confirmation Boring (2008)
- Existing Monitoring Well
- Abandoned Monitoring Well
- Site Boundary
- 220 Former Building
- Cross Section Location

Approximate Utilities

- Natural Gas
- Sanitary Sewer
- Telephone
- Water

0 30 60 Feet

FIGURE 4
LOCATION OF
CROSS-SECTION A-A'
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

CH2MHILL

RDD \\BALDUR\PROJ\SLOP_349765\MAPFILES\UFP_QAPP\FIG4_CROSSECTION_A_A_QAPP.MXD MSCHROCK 11/14/2012 11:58:12 PM

SW

NE

AMSL

560'

550'

540'

530'

520'

510'

500'

MW-115

557.64

CB-02

MW-118

553.64

CONCRETE / BASE ROCK

553.55

FILL

SB-023

CONCRETE

541.00

MW-117
(ABANDONED)

MW-119

541.44

STRATFORD AVENUE

MW-110

SB-028

SB-031

MW-108

CONCRETE

MW-116

534.29

534.97

534.05

535.01

534.48

ML

CL

CH

FILL

ASPHALT

WEATHERED SHALE

LAGONDA FORMATION

SH (COMPETENT)

COAL

0'

30'

60'

90'

120'

150'

180'

210'

240'

270'

300'

330'

A

A'

CL = LEAN CLAY

FILL

ML = SILT

CH = FAT CLAY

POTENTIOMETRIC SURFACE

AMSL ABOVE MEAN SEA LEVEL

COAL

WEATHERED SHALE

SH (COMPETENT)

LENS OF HIGHER PERMEABILITY SOIL

INFERRED

0 30 60 90

Scale In Feet

NOTES:

1. NOT ALL SOIL LENSES ARE DEPICTED.
2. GROUNDWATER LEVEL FROM MW-119 WAS NOT USED FOR THIS FIGURE. WATER LEVEL HAS NOT STABILIZED SINCE SOIL MIXING ACTIVITIES HAVE CEASED.

FIGURE 5
GEOLOGIC CROSS SECTION A-A'

St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

01nf005d 364298.dgn

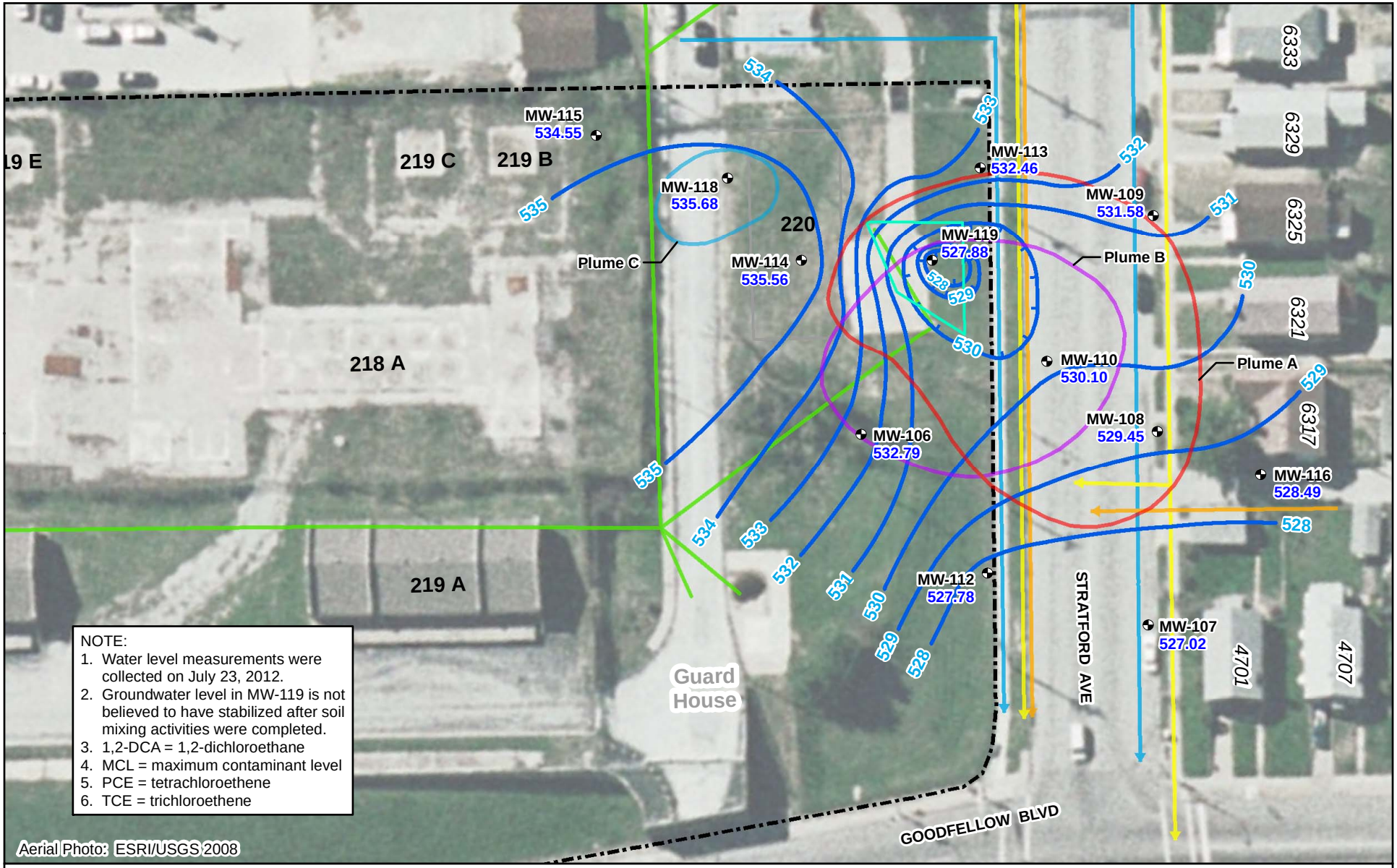
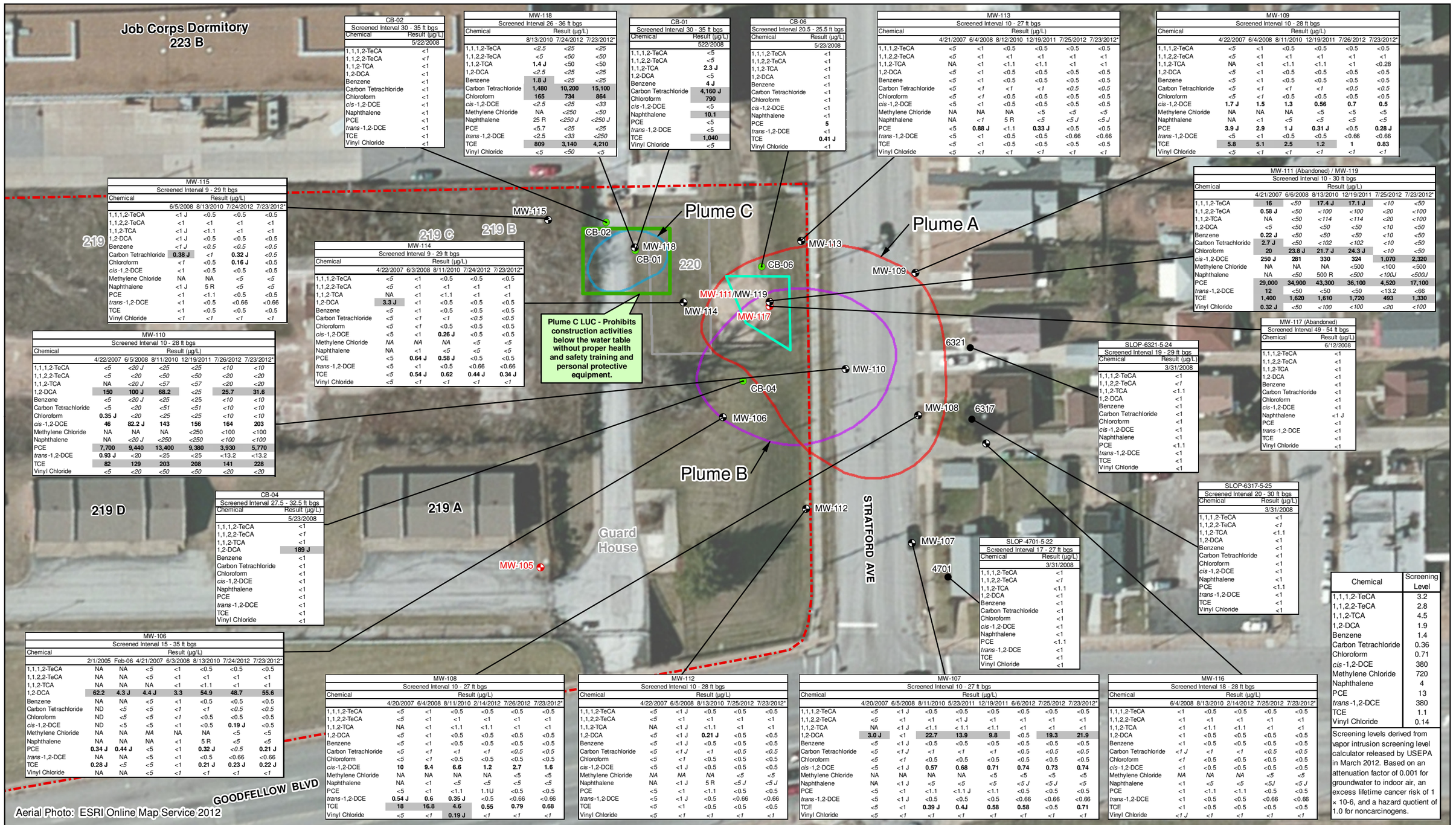


FIGURE 6
POTENTIOMETRIC SURFACE MAP
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

CH2MHILL

RDD \\BALDUR\PROJ\SLOP_349765\MAPFILES\UFP_QAPP\FIG6_POT_SURF_JULY2012_QAPP.MXD MSCHROCK 11/15/2012 12:25:17 AM



CB-02 — Screened Interval 30 - 35 ft bgs

Chemical	Result (µg/L) 5/22/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	<1
1,1,2-TCA	<1
1,2-DCA	<1
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1
PCE	<1
trans-1,2-DCE	<1
TCE	<1
Vinyl Chloride	<1

MW-118 — Screened Interval 26 - 36 ft bgs

Chemical	8/13/2010	7/24/2012	7/23/2012*
1,1,1,2-TeCA	*<2.5*	*<25*	*<25*
1,1,2,2-TeCA	*<5*	*<50*	*<50*
1,1,2-TCA	**1.4 J**	<50	<50
1,2-DCA	*<2.5*	*<25*	*<25*
Benzene	**1.8 J**	*<25*	*<25*
Carbon Tetrachloride	**1,480**	**10,200**	**15,100**
Chloroform	**165**	**734**	**864**
cis-1,2-DCE	*<2.5*	*<25*	*<33*
Methylene Chloride	NA	*<250*	*<50*
Naphthalene	25 R	*<250 J*	*<250 J*
PCE	<5.7	*<25*	*<25*
trans-1,2-DCE	*<2.5*	*<33*	*<250*
TCE	**809**	**3,140**	**4,210**
Vinyl Chloride	*<5*	*<50*	*<5*

CB-01 — Screened Interval 30 - 35 ft bgs

Chemical	Result (µg/L) 5/22/2008
1,1,1,2-TeCA	<5
1,1,2,2-TeCA	<5
1,1,2-TCA	**2.3 J**
1,2-DCA	<5
Benzene	**4 J**
Carbon Tetrachloride	**4,160 J**
Chloroform	**790**
cis-1,2-DCE	<5
Naphthalene	**10.1**
PCE	<5
trans-1,2-DCE	<5
TCE	**1,040**
Vinyl Chloride	*<5*

CB-06 — Screened Interval 20.5 - 25.5 ft bgs

Chemical	Result (µg/L) 5/23/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	<1
1,1,2-TCA	<1
1,2-DCA	<1
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1
PCE	**5**
trans-1,2-DCE	<1
TCE	**0.41 J**
Vinyl Chloride	<1

MW-113 — Screened Interval 10 - 27 ft bgs

Chemical	4/21/2007	6/4/2008	8/12/2010	12/19/2011	7/25/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	<1	<0.5	<0.5	<0.5	<0.5
1,1,2,2-TeCA	*<5*	<1	<1	<1	<1	<1
1,1,2-TCA	NA	<1	<1.1	<1.1	<1	<1
1,2-DCA	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Benzene	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<5*	<1	*<1*	*<1*	*<0.5*	*<0.5*
Chloroform	*<5*	*<1*	<0.5	<0.5	<0.5	<0.5
cis-1,2-DCE	<5	<1	<0.5	<0.5	<0.5	<0.5
Methylene Chloride	NA	NA	NA	<5	*<5*	*<5*
Naphthalene	NA	*<1*	5 R	*<5*	*<5 J*	*<5 J*
PCE	<5	**0.88 J**	<1.1	**0.33 J**	<0.5	<0.5
trans-1,2-DCE	<5	<1	<0.5	<0.5	<0.66	<0.66
TCE	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Vinyl Chloride	*<5*	*<1*	*<1*	*<1*	*<1*	*<1*

MW-109 — Screened Interval 10 - 28 ft bgs

Chemical	4/22/2007	6/4/2008	8/11/2010	12/19/2011	7/26/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	<1	<0.5	<0.5	<0.5	<0.5
1,1,2,2-TeCA	*<5*	<1	<1	<1	<1	<1
1,1,2-TCA	NA	<1	<1.1	<1.1	<1	<0.28
1,2-DCA	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Benzene	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<5*	<1	*<1*	*<1*	*<0.5*	*<0.5*
Chloroform	*<5*	*<1*	<0.5	<0.5	<0.5	<0.5
cis-1,2-DCE	**1.7 J**	**1.5**	**1.3**	**0.56**	**0.7**	**0.5**
Methylene Chloride	NA	NA	NA	<5	<5	<5
Naphthalene	NA	<1	*<5*	<5	<5	<5
PCE	**3.9 J**	**2.9**	**1 J**	**0.31 J**	<0.5	**0.28 J**
trans-1,2-DCE	*<5*	<1	<0.5	<0.5	<0.66	<0.66
TCE	**5.8**	**5.1**	**2.5**	**1.2**	**1**	**0.83**
Vinyl Chloride	*<5*	*<1*	*<1*	*<1*	*<1*	*<1*

MW-115 — Screened Interval 9 - 29 ft bgs

Chemical	6/5/2008	8/13/2010	7/24/2012	7/23/2012*
1,1,1,2-TeCA	<1 J	<0.5	<0.5	<0.5
1,1,2,2-TeCA	<1	<1	<1	<1
1,1,2-TCA	<1 J	<1.1	<1	<1
1,2-DCA	<1 J	<0.5	<0.5	<0.5
Benzene	*<1 J*	*<0.5*	*<0.5*	*<0.5*
Carbon Tetrachloride	**0.38 J**	*<1*	**0.32 J**	<0.5
Chloroform	*<1*	<0.5	**0.16 J**	<0.5
cis-1,2-DCE	<1	<0.5	<0.5	<0.5
Methylene Chloride	NA	NA	*<5*	*<5*
Naphthalene	<1 J	5 R	*<5*	*<5*
PCE	<1	<1.1	<0.5	<0.5
trans-1,2-DCE	<1	<0.5	<0.66	<0.66
TCE	<1	<0.5	<0.5	<0.5
Vinyl Chloride	*<1*	*<1*	*<1*	*<1*

MW-114 — Screened Interval 9 - 29 ft bgs

Chemical	4/22/2007	6/3/2008	8/11/2010	7/24/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	<1	<0.5	<0.5	<0.5
1,1,2,2-TeCA	*<5*	<1	<1	<1	<1
1,1,2-TCA	NA	<1	<1.1	<1	<1
1,2-DCA	**3.3 J**	<1	<0.5	<0.5	<0.5
Benzene	*<5*	<1	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<5*	*<1*	*<1*	*<0.5*	*<0.5*
Chloroform	*<5*	*<1*	<0.5	<0.5	<0.5
cis-1,2-DCE	<5	<1	**0.26 J**	<0.5	<0.5
Methylene Chloride	*NA*	*NA*	*NA*	*<5*	*<5*
Naphthalene	NA	<1	*<5*	*<5*	*<5*
PCE	<5	**0.64 J**	**0.58 J**	<0.5	<0.5
trans-1,2-DCE	<5	<1	<0.5	<0.66	<0.66
TCE	*<5*	**0.54 J**	**0.62**	**0.44 J**	**0.34 J**
Vinyl Chloride	*<5*	*<1*	*<1*	*<1*	*<1*

MW-111 (Abandoned) / MW-119 — Screened Interval 10 - 30 ft bgs

Chemical	4/21/2007	6/6/2008	8/13/2010	12/19/2011	7/25/2012	7/23/2012*
1,1,1,2-TeCA	**16**	*<50*	**17.4 J**	**17.1 J**	*<10*	*<50*
1,1,2,2-TeCA	**0.58 J**	*<50*	*<100*	*<100*	*<20*	*<100*
1,1,2-TCA	NA	*<50*	*<114*	*<114*	*<20*	*<100*
1,2-DCA	*<5*	*<50*	*<50*	*<50*	*<10*	*<50*
Benzene	**0.22 J**	*<50*	*<50*	*<50*	*<10*	*<50*
Carbon Tetrachloride	**2.7 J**	*<50*	*<102*	*<102*	*<10*	*<50*
Chloroform	**20**	**23.8 J**	**21.7 J**	**24.3 J**	*<10*	*<50*
cis-1,2-DCE	**250 J**	**281**	**330**	**324**	**1,070**	**2,320**
Methylene Chloride	NA	NA	NA	<500	<100	<500
Naphthalene	NA	*<50*	500 R	*<500*	*<100J*	*<500J*
PCE	**29,000**	**34,900**	**43,300**	**36,100**	**4,520**	**17,100**
trans-1,2-DCE	**12**	<50	<50	<50	<13.2	<66
TCE	**1,400**	**1,620**	**1,610**	**1,720**	**493**	**1,330**
Vinyl Chloride	**0.32 J**	*<50*	*<100*	*<100*	*<20*	*<100*

MW-110 — Screened Interval 10 - 28 ft bgs

Chemical	4/22/2007	6/5/2008	8/11/2010	12/19/2011	7/26/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	*<20 J*	*<25*	*<25*	*<10*	*<10*
1,1,2,2-TeCA	*<5*	*<20*	*<50*	*<50*	*<20*	*<20*
1,1,2-TCA	NA	*<20 J*	*<57*	*<57*	*<20*	*<20*
1,2-DCA	**150**	**100 J**	**68.2**	*<25*	**25.7**	**31.6**
Benzene	*<5*	*<20 J*	*<25*	<25	*<10*	*<10*
Carbon Tetrachloride	<5	*<20*	*<51*	*<51*	*<10*	*<10*
Chloroform	**0.35 J**	*<20*	*<25*	<25	*<10*	*<10*
cis-1,2-DCE	**46**	**82.2 J**	**143**	**156**	**164**	**203**
Methylene Chloride	NA	NA	NA	<250	<100	<100
Naphthalene	NA	*<20 J*	*<250*	*<250*	*<100*	*<100*
PCE	**7,700**	**9,440**	**13,400**	**9,380**	**3,930**	**5,770**
trans-1,2-DCE	**0.93 J**	<20	<25	<25	<13.2	<13.2
TCE	**82**	**129**	**203**	**208**	**141**	**228**
Vinyl Chloride	*<5*	*<20*	*<50*	*<50*	*<20*	*<20*

MW-117 (Abandoned) — Screened Interval 49 - 54 ft bgs

Chemical	Result (µg/L) 6/12/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	<1
1,1,2-TCA	<1
1,2-DCA	<1
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1 J
PCE	<1
trans-1,2-DCE	<1
TCE	<1
Vinyl Chloride	<1

SLOP-6321-5-24 — Screened Interval 19 - 29 ft bgs

Chemical	Result (µg/L) 3/31/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	*<1*
1,1,2-TCA	<1.1
1,2-DCA	<1
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1
PCE	<1.1
trans-1,2-DCE	<1
TCE	<1
Vinyl Chloride	<1

SLOP-6317-5-25 — Screened Interval 20 - 30 ft bgs

Chemical	Result (µg/L) 3/31/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	*<1*
1,1,2-TCA	<1.1
1,2-DCA	<1
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1
PCE	<1.1
trans-1,2-DCE	<1
TCE	<1
Vinyl Chloride	<1

SLOP-4701-5-22 — Screened Interval 17 - 27 ft bgs

Chemical	Result (µg/L) 3/31/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	*<1*
1,1,2-TCA	<1.1
1,2-DCA	<1
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1
PCE	<1.1
trans-1,2-DCE	<1
TCE	<1
Vinyl Chloride	<1

CB-04 — Screened Interval 27.5 - 32.5 ft bgs

Chemical	Result (µg/L) 5/23/2008
1,1,1,2-TeCA	<1
1,1,2,2-TeCA	*<1*
1,1,2-TCA	<1
1,2-DCA	**189 J**
Benzene	<1
Carbon Tetrachloride	<1
Chloroform	<1
cis-1,2-DCE	<1
Naphthalene	<1
PCE	<1
trans-1,2-DCE	<1
TCE	<1
Vinyl Chloride	<1

MW-106 — Screened Interval 15 - 35 ft bgs

Chemical	2/1/2005	Feb-06	4/21/2007	6/3/2008	8/13/2010	7/24/2012	7/23/2012*
1,1,1,2-TeCA	NA	NA	*<5*	<1	<0.5	<0.5	<0.5
1,1,2,2-TeCA	NA	NA	*<5*	<1	<1	<1	<1
1,1,2-TCA	NA	NA	NA	<1	<1.1	<1	<1
1,2-DCA	**62.2**	**4.3 J**	**4.4 J**	**3.3**	**54.9**	**48.7**	**55.6**
Benzene	NA	NA	*<5*	<1	<0.5	<0.5	<0.5
Carbon Tetrachloride	ND	*<5*	*<5*	*<1*	*<1*	*<0.5*	*<0.5*
Chloroform	ND	*<5*	*<5*	*<1*	<0.5	<0.5	<0.5
cis-1,2-DCE	ND	<5	<5	<1	<0.5	**0.19 J**	<0.5
Methylene Chloride	NA	NA	*NA*	NA	NA	<5	<5
Naphthalene	NA	NA	NA	<1	5 R	*<5*	*<5*
PCE	**0.34 J**	**0.44 J**	*<5*	<1	**0.32 J**	*<0.5*	**0.21 J**
trans-1,2-DCE	NA	NA	<5	<1	<0.5	<0.66	<0.66
TCE	**0.28 J**	*<5*	*<5*	<1	**0.21 J**	**0.23 J**	**0.22 J**
Vinyl Chloride	NA	NA	*<5*	*<1*	*<1*	*<1*	*<1*

MW-108 — Screened Interval 10 - 27 ft bgs

Chemical	4/20/2007	6/4/2008	8/11/2010	2/14/2012	7/26/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	<1	<0.5	<0.5	<0.5	<0.5
1,1,2,2-TeCA	*<5*	<1	<1	<1	<1	<1
1,1,2-TCA	NA	<1	<1.1	<1.1	<1	<1
1,2-DCA	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Benzene	*<5*	<1	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<5*	*<1*	*<1*	*<0.5*	*<0.5*	*<0.5*
Chloroform	*<5*	*<1*	<0.5	<0.5	<0.5	<0.5
cis-1,2-DCE	**10**	**9.4**	**6.6**	**1.2**	**2.7**	**1.6**
Methylene Chloride	NA	NA	NA	NA	<5	<5
Naphthalene	NA	<1	*<5*	*<5*	*<5*	*<5*
PCE	<5	<1	<1.1	1.1U	<0.5	<0.5
trans-1,2-DCE	**0.54 J**	**0.6**	**0.35 J**	<0.5	<0.66	<0.66
TCE	**18**	**16.8**	**4.6**	**0.55**	**0.79**	**0.68**
Vinyl Chloride	*<5*	*<1*	**0.19 J**	*<1*	*<1*	*<1*

MW-112 — Screened Interval 10 - 28 ft bgs

Chemical	4/22/2007	6/5/2008	8/13/2010	7/25/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	*<1 J*	<0.5	<0.5	<0.5
1,1,2,2-TeCA	*<5*	<1	<1	<1	<1
1,1,2-TCA	NA	*<1 J*	*<1.1*	<1	<1
1,2-DCA	*<5*	*<1 J*	**0.21 J**	<0.5	<0.5
Benzene	*<5*	*<1 J*	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<5*	*<1 J*	*<1*	*<0.5*	*<0.5*
Chloroform	*<5*	*<1*	<0.5	<0.5	<0.5
cis-1,2-DCE	*<5*	*<1 J*	<0.5	<0.5	<0.5
Methylene Chloride	*NA*	*NA*	*NA*	*<5*	*<5*
Naphthalene	NA	*<1 J*	5 R	*<5 J*	*<5 J*
PCE	*<5*	<1	*<1.1*	<0.5	<0.5
trans-1,2-DCE	*<5*	*<1 J*	<0.5	<0.66	<0.66
TCE	*<5*	<1	<0.5	<0.5	<0.5
Vinyl Chloride	*<5*	*<1*	*<1*	*<1*	*<1*

MW-107 — Screened Interval 10 - 27 ft bgs

Chemical	4/20/2007	6/5/2008	8/11/2010	5/23/2011	12/19/2011	6/6/2012	7/25/2012	7/23/2012*
1,1,1,2-TeCA	*<5*	*<1 J*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2,2-TeCA	*<5*	<1	<1	*<1 J*	<1	<1	<1	<1
1,1,2-TCA	NA	*<1 J*	*<1.1*	< 1.1	*<1.1*	<1	<1	<1
1,2-DCA	**3.0 J**	<1	**22.7**	**13.9**	**9.8**	<0.5	**19.3**	**21.9**
Benzene	*<5*	*<1 J*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<5*	*<1 J*	*<1*	*<1*	*<1*	<0.5	*<0.5*	*<0.5*
Chloroform	*<5*	*<1*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
cis-1,2-DCE	<5	*<1 J*	**0.57**	**0.68**	**0.71**	**0.74**	**0.73**	**0.74**
Methylene Chloride	NA	NA	NA	NA	<5	<5	<5	<5
Naphthalene	NA	*<1 J*	*<5*	*<5*	*<5 J*	<5	*<5 J*	*<5*
PCE	<5	<1	<1.1	*<1.1 J*	<1.1	<0.5	<0.5	<0.5
trans-1,2-DCE	<5	*<1 J*	<0.5	<0.5	<0.5	<0.66	<0.66	<0.66
TCE	*<5*	<1	**0.39 J**	**0.4J**	**0.58**	**0.58**	<0.5	**0.71**
Vinyl Chloride	*<5*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*

MW-116 — Screened Interval 18 - 28 ft bgs

Chemical	6/4/2008	8/13/2010	2/14/2012	7/25/2012	7/23/2012*
1,1,1,2-TeCA	<1	<0.5	<0.5	<0.5	<0.5
1,1,2,2-TeCA	<1	<1	<1	<1	<1
1,1,2-TCA	<1	<1.1	<1.1	<1	<1
1,2-DCA	<1	<0.5	<0.5	<0.5	<0.5
Benzene	<1	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	*<1 J*	*<1*	*<1*	*<0.5*	*<0.5*
Chloroform	*<1*	<0.5	<0.5	<0.5	<0.5
cis-1,2-DCE	<1	<0.5	<0.5	<0.5	<0.5
Methylene Chloride	*NA*	*NA*	*NA*	*<5*	*<5*
Naphthalene	<1	*<5*	*<5*	*<5J*	*<5 J*
PCE	<1	<1.1	<1.1	<0.5	<0.5
trans-1,2-DCE	<1	<0.5	<0.5	<0.66	<0.66
TCE	<1	<0.5	<0.5	<0.5	<0.5
Vinyl Chloride	*<1 J*	<1	*<1*	*<1*	*<1*

Chemical	Screening Level
1,1,1,2-TeCA	3.2
1,1,2,2-TeCA	2.8
1,1,2-TCA	4.5
1,2-DCA	1.9
Benzene	1.4
Carbon Tetrachloride	0.36
Chloroform	0.71
cis-1,2-DCE	380
Methylene Chloride	720
Naphthalene	4
PCE	13
trans-1,2-DCE	380
TCE	1.1
Vinyl Chloride	0.14

Screening levels derived from vapor intrusion screening level calculator released by USEPA in March 2012. Based on an attenuation factor of 0.001 for groundwater to indoor air, an excess lifetime cancer risk of 1 × 10-6, and a hazard quotient of 1.0 for noncarcinogens.

LEGEND

- Existing Monitoring Well
- Abandoned Monitoring Well
- Groundwater Sample Point
- Temporary Well
- Site Boundary
- 220 Former Building
- Plume C LUC
- Soil Mixing Treatment Area
- Plume A (PCE, TCE, and cis-1,2-DCE)
- Plume B (1,2-DCA)
- Plume C (Carbon Tetrachloride)

0 30 60 Feet

NOTES:

1. VOC = volatile organic compound
2. TeCA = tetrachloroethane
3. TCA = trichloroethane
4. DCA = dichloroethane
5. DCE = dichloroethene
6. PCE = tetrachloroethene
7. TCE = trichloroethene
8. J = Estimated Concentration
9. < = Chemical not detected above the method detection limit.
10. Bold type indicates the chemical was detected.
11. Shading indicates a detected concentration above the screening level.
12. Italicized values represent detection limits above screening levels.
13. µg/L = micrograms per liter
14. NA = Not Analyzed
15. * July 23, 2012 groundwater samples collected using passive diffusion bags.

FIGURE 7
VOCs IN GROUNDWATER AT CONCENTRATIONS EXCEEDING VAPOR INTRUSION SCREENING LEVELS
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri
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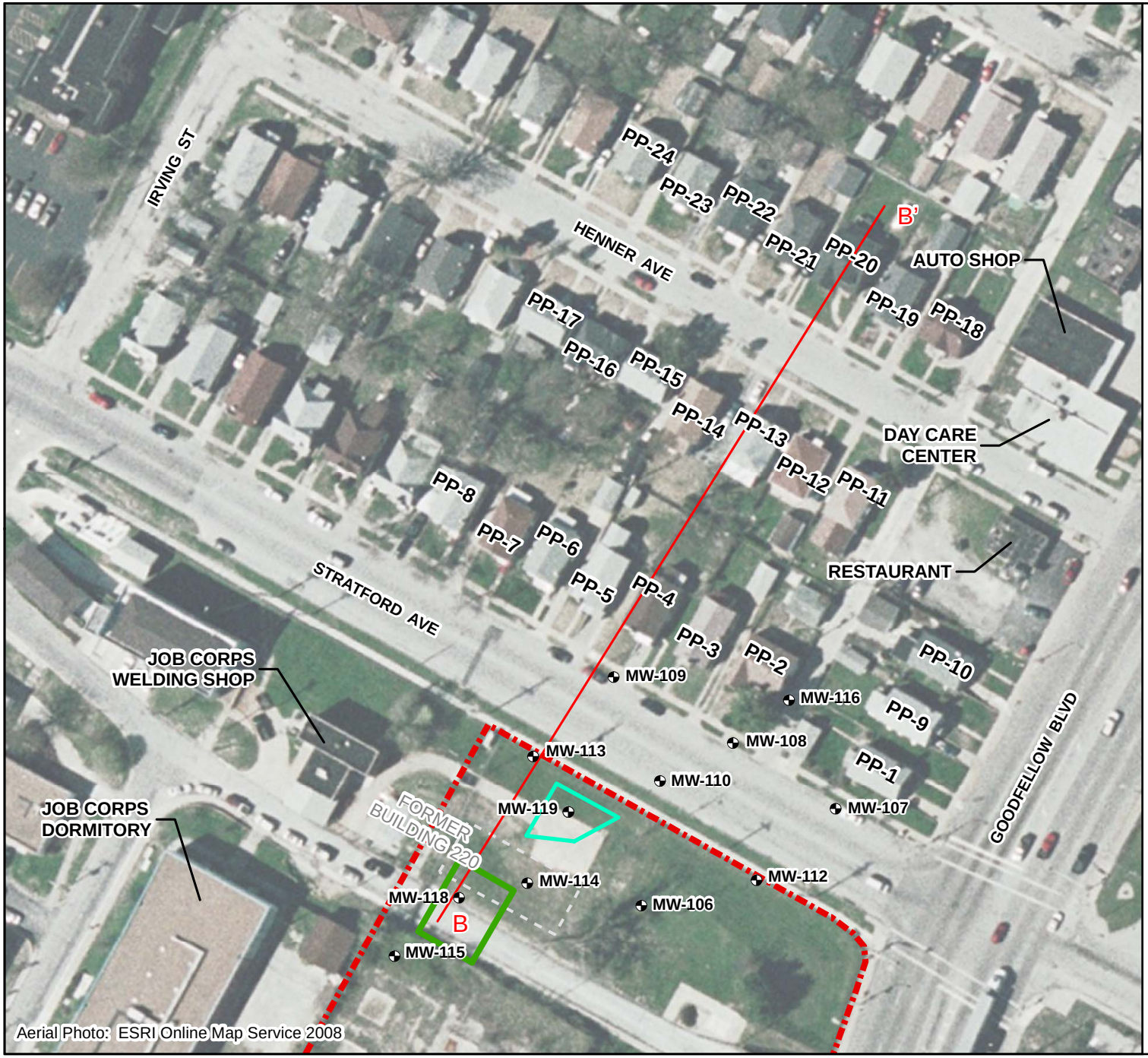

LEGEND

- Site Boundary
- Cross Section
- Land Use Control Boundary
- Soil Mixing Treatment Area
- Former Building
- Monitoring Well

N

0 50 100 Feet

FIGURE 8
CONCEPTUAL SITE MODEL
CROSS-SECTION
LOCATION B-B'
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

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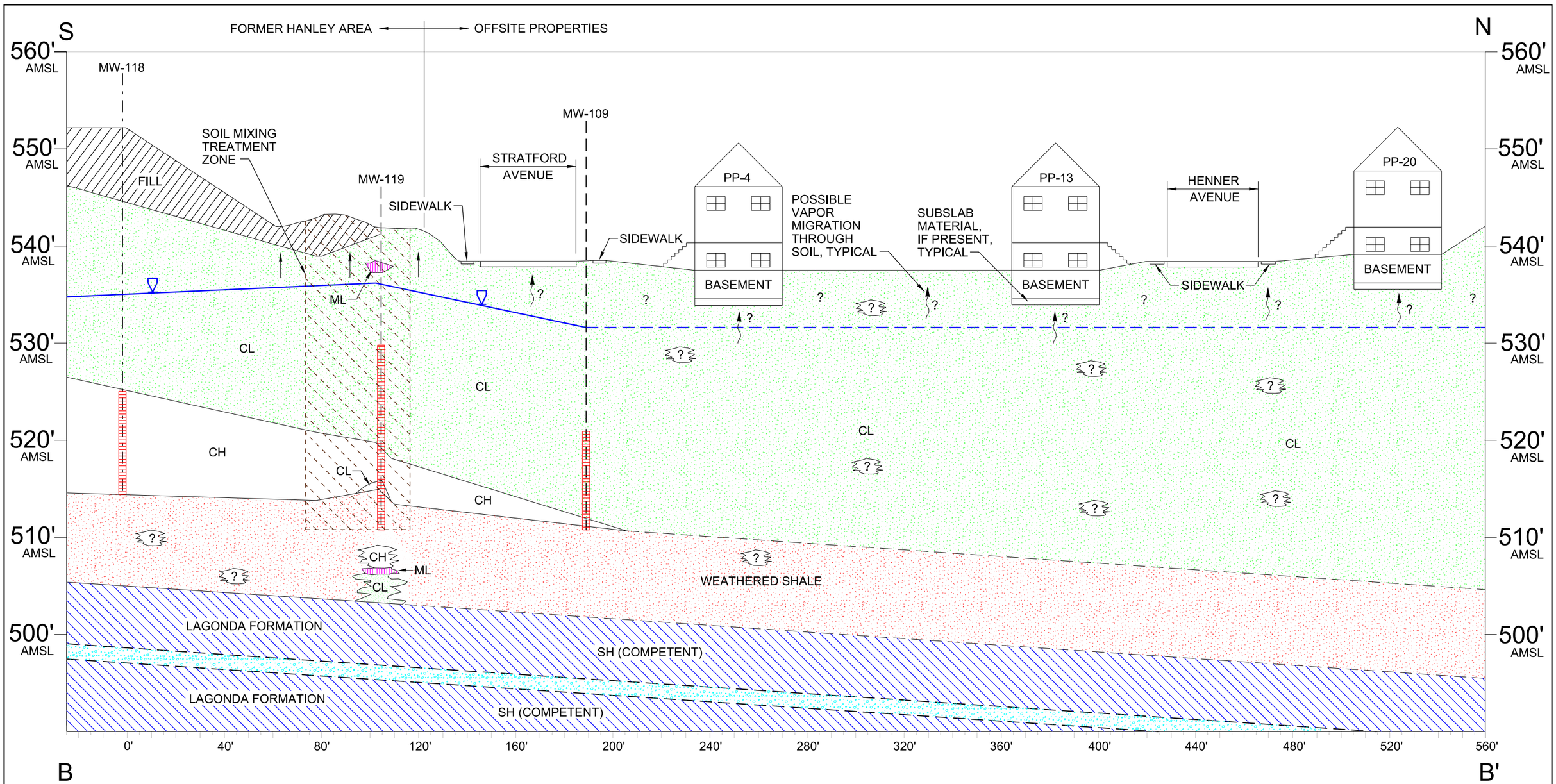

CH = FAT CLAY
CL = LEAN CLAY
FILL
ML = SILT
COAL
WEATHERED SHALE
SH (COMPETENT)

LENS OF HIGHER PERMEABILITY SOIL
INFERRED
POTENTIOMETRIC SURFACE
AMSL ABOVE MEAN SEA LEVEL
SOIL MIXING TREATMENT ZONE

0 40 80 120
SCALE IN FEET

NOTES:

1. WATER LEVEL AT FORMER MW-111 WAS USED TO CREATE POTENTIOMETRIC SURFACE NEAR MW-117.
2. GROUNDWATER LEVEL FROM MW-119 WAS NOT USED FOR THIS FIGURE. WATER LEVEL HAS NOT STABILIZED SINCE SOIL MIXING ACTIVITIES HAVE CEASED.

FIGURE 9
CONCEPTUAL SITE MODEL CROSS SECTION B - B'

St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

CH2MHILL

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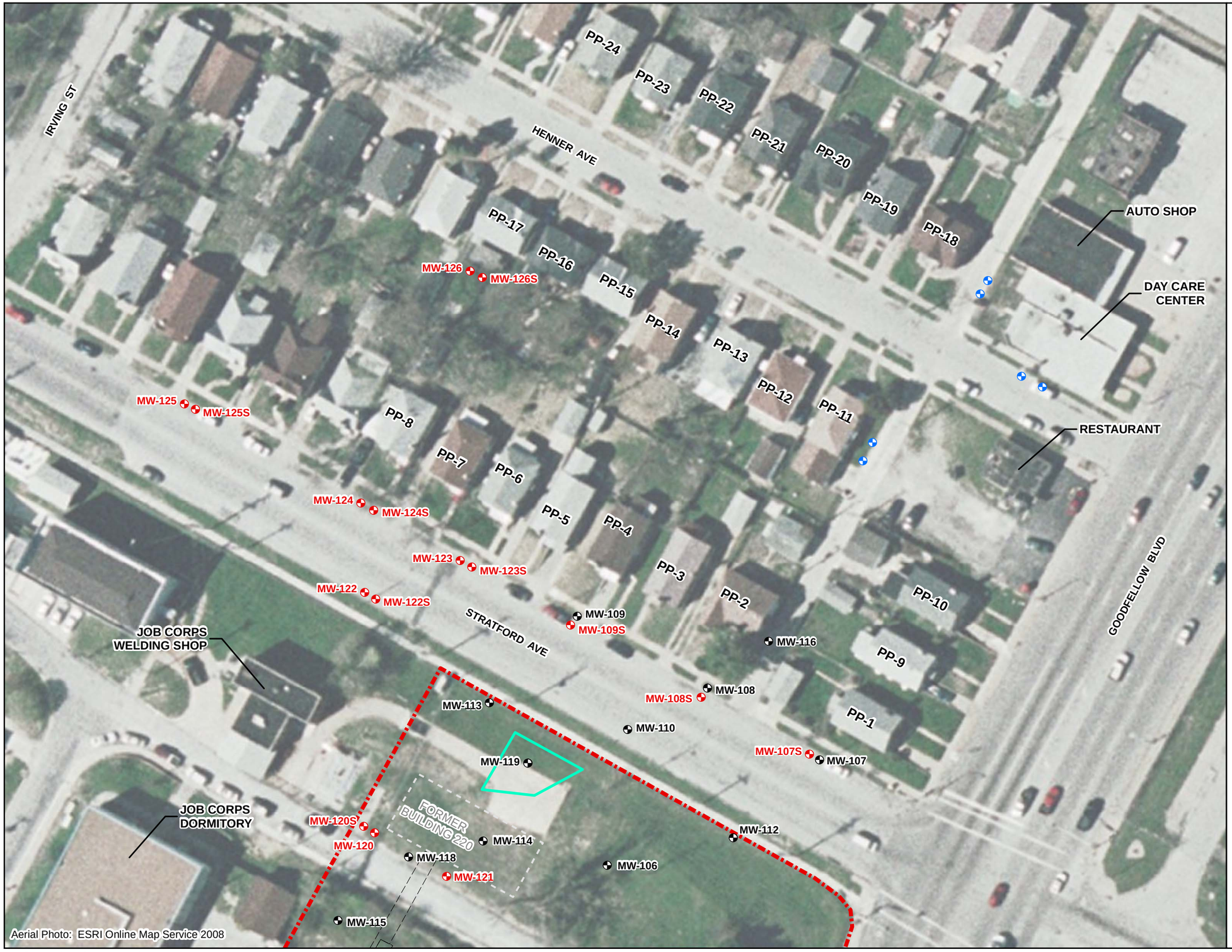

LEGEND
- Site Boundary
- Soil Mixing Treatment Area
- Former Building
- Tunnel System
- Monitoring Well
- Proposed Monitoring Well
- Proposed Co-Located Shallow and Deep Overburden Monitoring Wells near Day Care Center (If Warranted Based on Findings in Other Monitoring Wells)

N

0 30 60
Feet

FIGURE 10
PROPOSED CO-LOCATED MONITORING WELL LOCATIONS
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

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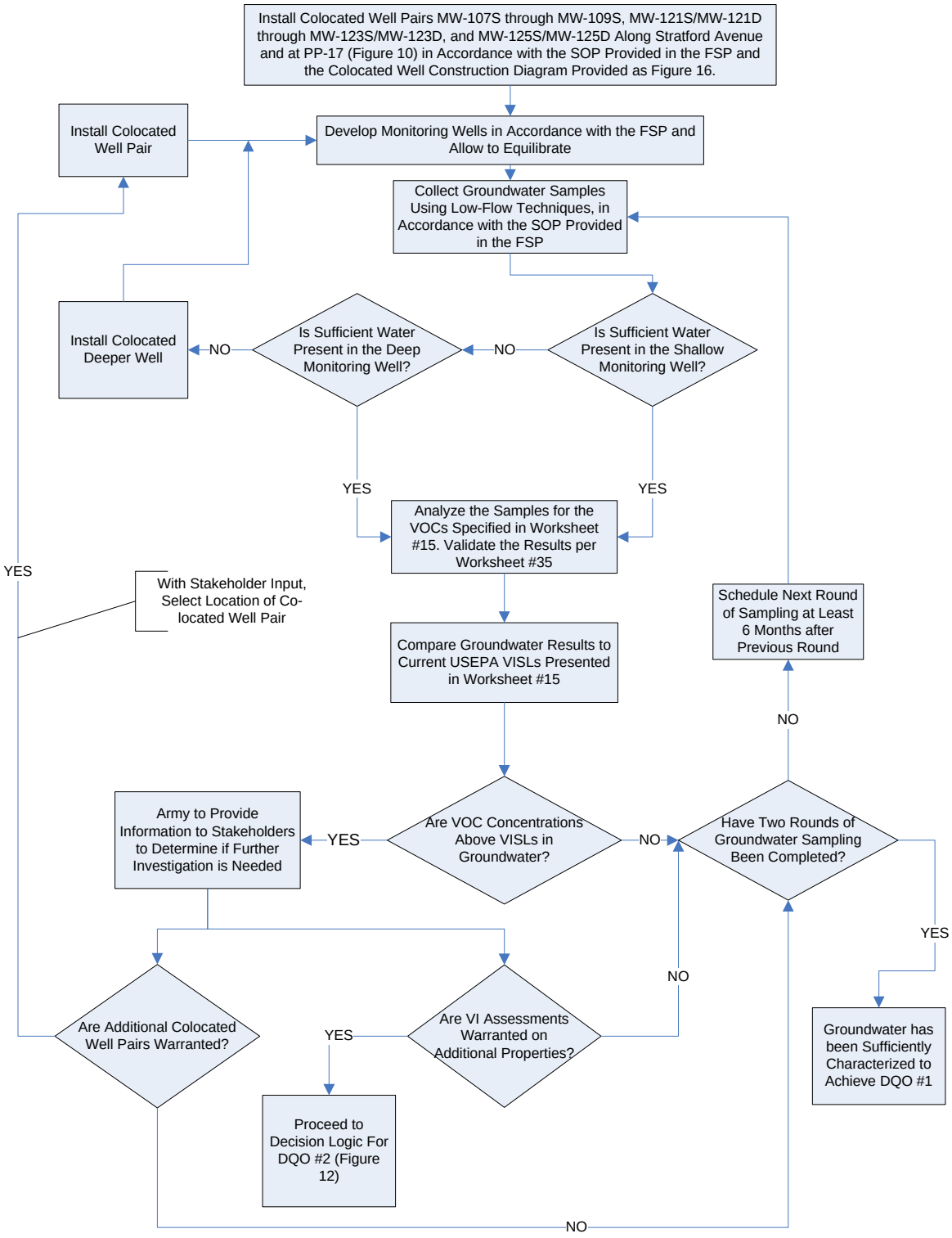
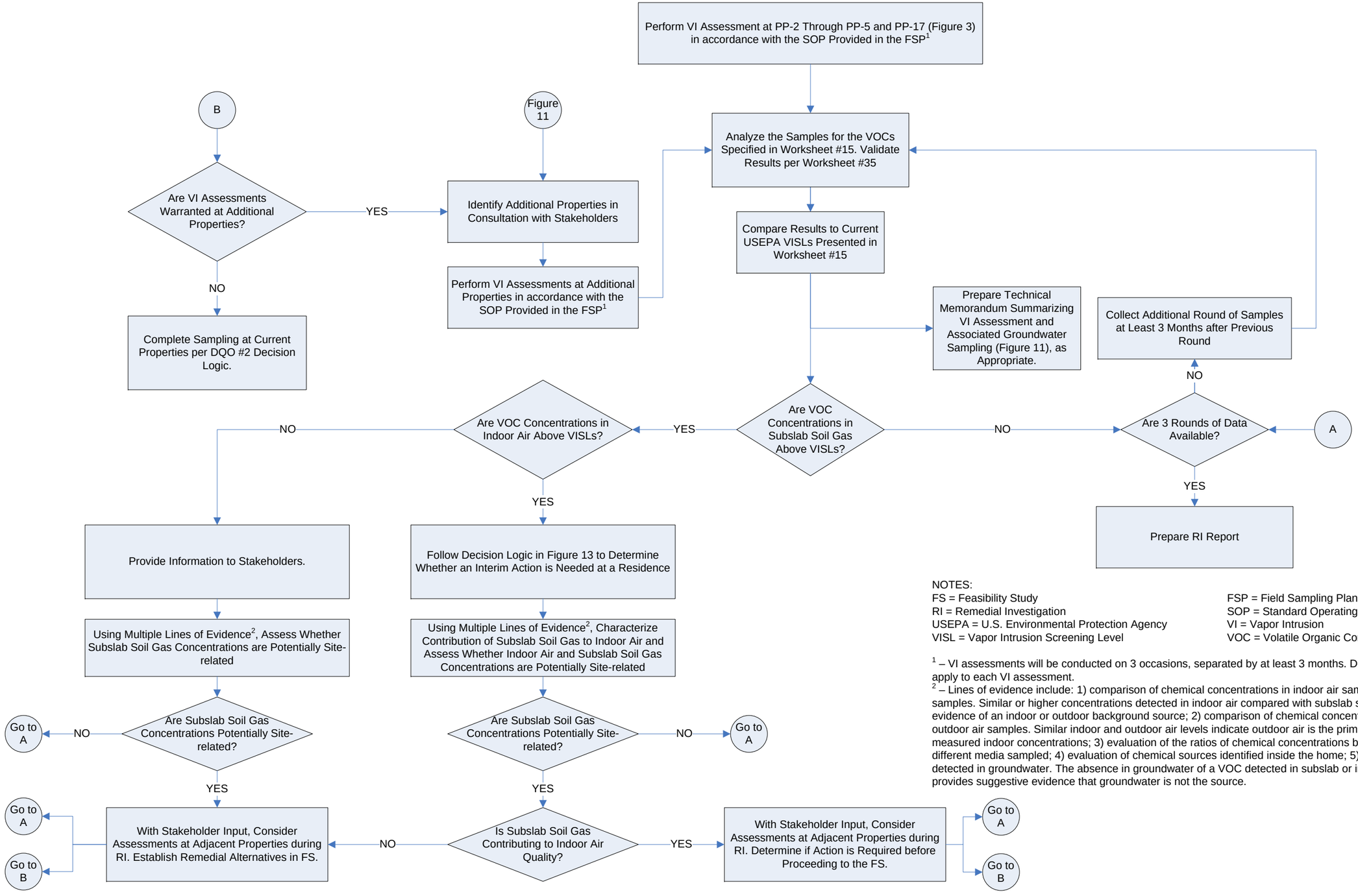


NOTES:
DQO = Data Quality Objective
FS = Feasibility Study
FSP = Field Sampling Plan
RI = Remedial Investigation
SOP = Standard Operating Procedure
USEPA = U.S. Environmental Protection Agency
VI = Vapor Intrusion
VISL = Vapor Intrusion Screening Level
VOC = Volatile Organic Compound

Figure 11
DQO #1 – Decision Logic for the Groundwater Investigation Along Stratford Avenue and at PP-17
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri



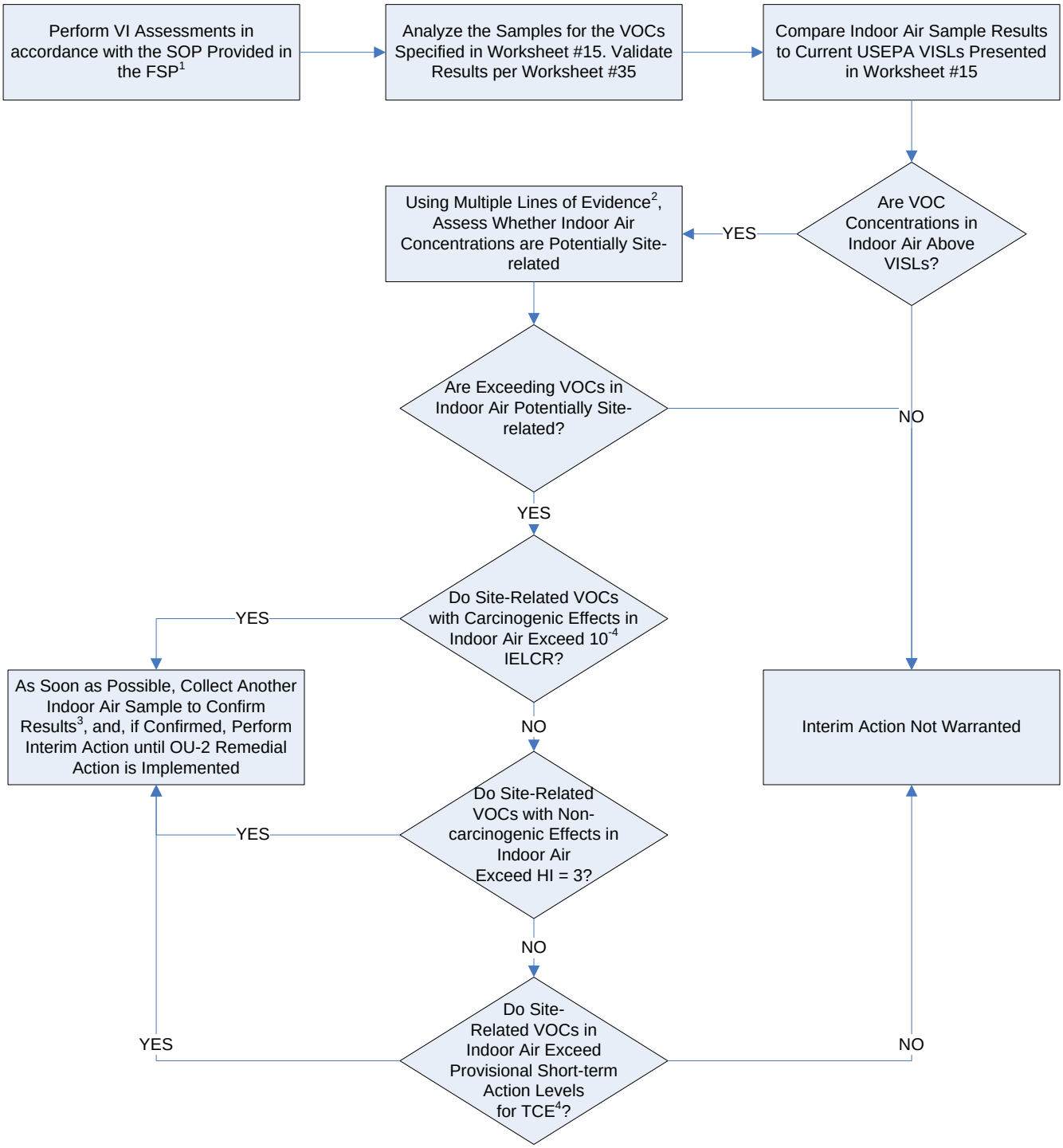
NOTES:

FS = Feasibility Study	FSP = Field Sampling Plan
RI = Remedial Investigation	SOP = Standard Operating Procedure
USEPA = U.S. Environmental Protection Agency	VI = Vapor Intrusion
VISL = Vapor Intrusion Screening Level	VOC = Volatile Organic Compound

[1] – VI assessments will be conducted on 3 occasions, separated by at least 3 months. Decision logic shown will apply to each VI assessment.

[2] – Lines of evidence include: 1) comparison of chemical concentrations in indoor air samples and subslab samples. Similar or higher concentrations detected in indoor air compared with subslab soil gas samples provide evidence of an indoor or outdoor background source; 2) comparison of chemical concentrations in indoor air and outdoor air samples. Similar indoor and outdoor air levels indicate outdoor air is the primary source of the measured indoor concentrations; 3) evaluation of the ratios of chemical concentrations between or within the different media sampled; 4) evaluation of chemical sources identified inside the home; 5) evaluation of chemicals detected in groundwater. The absence in groundwater of a VOC detected in subslab or indoor air samples provides suggestive evidence that groundwater is not the source.

Figure 12
DQO #2 – Decision Logic for VI Assessments
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

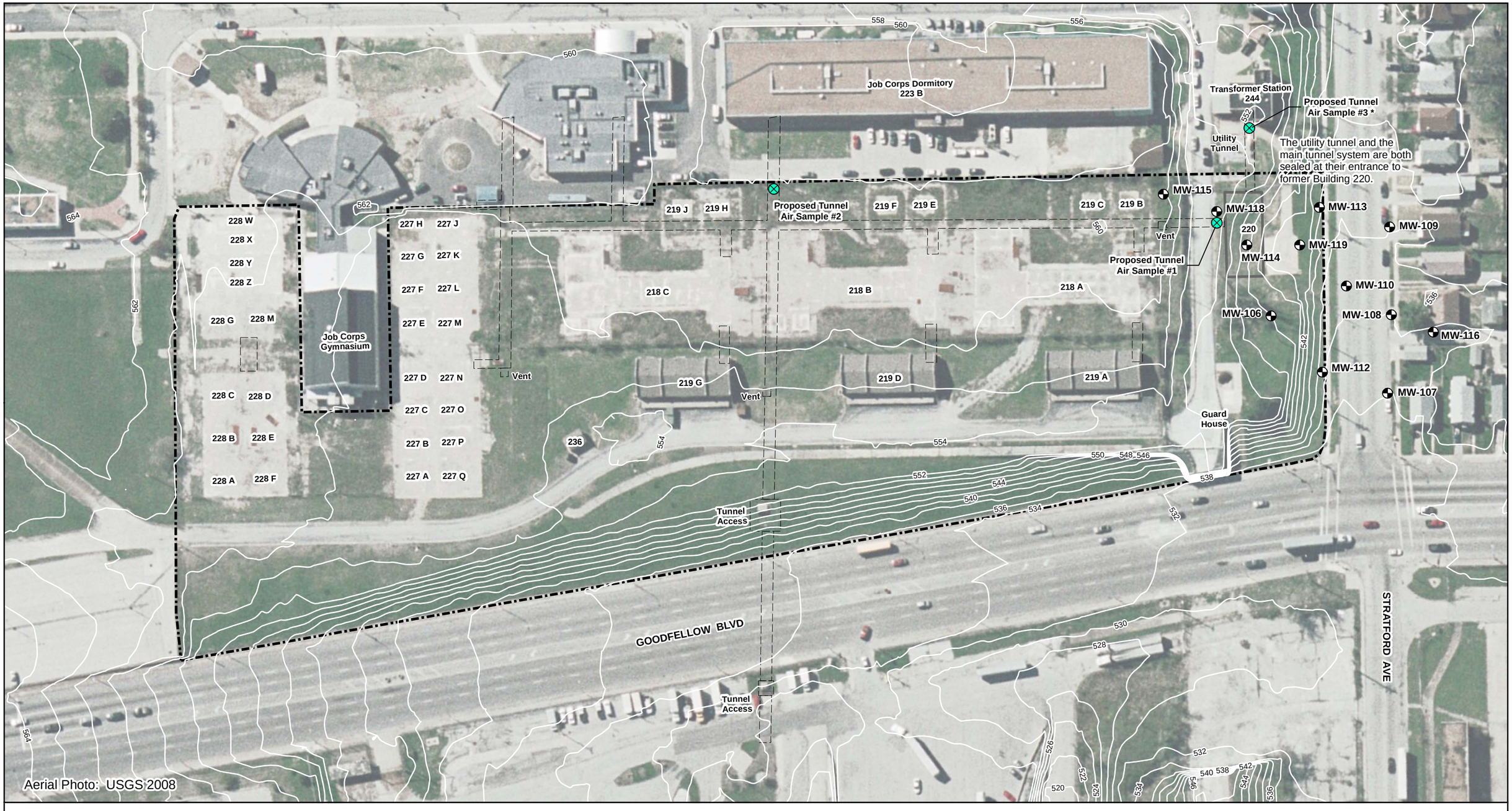


NOTES:

FSP = Field Sampling Plan
IECLR = Individual Excess Lifetime Cancer Risk
SOP = Standard Operating Procedure
VI = Vapor Intrusion
VOC = Volatile Organic Compound
HI = Hazard Index
OU = Operable Unit
USEPA = U.S. Environmental Protection Agency
VISL = Vapor Intrusion Screening Level

[1] – VI assessments will be conducted on 3 occasions, separated by at least 3 months. Decision logic shown will apply to each VI assessment.
[2] – Lines of evidence are summarized in the notes on Figure 12..
[3] – Confirmation indoor air sampling is optional; Army may elect to implement interim action without confirmation samples.
[4] – The Army will discuss indoor air TCE concentrations with MDNR to determine an appropriate next step if indoor air concentrations of TCE exceed one or more of the provisional short-term action levels for TCE that are used by USEPA to make risk management decisions.

Figure 13
Decision Logic for Implementing an Interim Action at a Residence in Response to VI Assessment Findings
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri



0 50 100 Feet

LEGEND

- Monitoring Well
- Backfilled Powder Well
- Proposed Tunnel Air Sample Location
- Tunnel System
- Elevation Contour (2-foot interval)
- Site Boundary
- 220 Former Building

NOTE:
1. Elevation contours were obtained from St. Louis Metropolitan Sewer District
2. * - Collection of Tunnel Air Sample #3 is contingent on receiving permission from the Job Corps to collect the sample.

FIGURE 14
PROPOSED TUNNEL AIR SAMPLE LOCATIONS
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

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Figure 15
Project Schedule
Operable Unit 2 Remedial Investigation / Feasiblity Study
St. Louis Ordnance Plant, St. Louis, Missouri

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Project Award**	0 days	Mon 8/27/12	Mon 8/27/12	
2	**Project Management Plan (PMP) and Quality Control Plan (QCP)**	**94 days**	**Mon 8/27/12**	**Fri 1/4/13**	
3	Army Awards PMP and QCP (Tasks 1 and 2)	0 days	Mon 8/27/12	Mon 8/27/12	
4	Prepare Draft PMP and QCP	60 edays	Mon 8/27/12	Fri 10/26/12	3
5	Project Kickoff Meeting in Kansas City	1 day	Wed 9/19/12	Wed 9/19/12	1FS+23 edays
6	Submit Draft Plans to Army (USACE, USAEC, 88th RSC)	0 days	Fri 10/26/12	Fri 10/26/12	4
7	Army Review of Plans	52 edays	Fri 10/26/12	Mon 12/17/12	6
8	Prepare Responses to Army Comments and Update Plans	18 edays	Mon 12/17/12	Fri 1/4/13	7
9	Submit Final Plans to Army	0 days	Fri 1/4/13	Fri 1/4/13	8
10	**Work Planning**	**276 days**	**Mon 8/27/12**	**Sun 9/15/13**	
11	Army Awards RI Work Plan Option (Task 3)	0 days	Mon 8/27/12	Mon 8/27/12	
12	Prepare Draft Sampling and Analysis Plan (SAP) and Accident Prevention Plan / Site Safety and Health Plan (APP/SSHP)	63 days	Mon 8/27/12	Wed 11/21/12	11
13	Submit Draft Work Plans to Army	0 days	Wed 11/21/12	Wed 11/21/12	12
14	Army Review of Draft Work Plans	37 edays	Wed 11/21/12	Fri 12/28/12	13
15	Prepare Responses to Army Comments and Update Work Plans / Conduct Initial Site Visits with Residents	29 days	Mon 12/31/12	Thu 2/7/13	14
16	Submit Draft Final Work Plans to Army and MDNR	0 days	Thu 2/7/13	Thu 2/7/13	15
17	MDNR and USEPA Review of Work Plans	34 edays	Thu 2/7/13	Wed 3/13/13	16
18	Prepare Responses to MDNR and USEPA Comments	42 edays	Wed 3/13/13	Wed 4/24/13	17
19	MDNR and USEPA Review of Army Responses; MDNR Submits Responses	26 edays	Wed 4/24/13	Mon 5/20/13	18
20	Army Prepares Responses to MDNR Correspondence	32 edays	Mon 5/20/13	Fri 6/21/13	19
21	Teleconference to Discuss Army Responses to MDNR Correspondence	1 day	Thu 7/25/13	Thu 7/25/13	
22	Army Prepares Final Responses and Final Work Plan for Army and MDNR	52 edays	Thu 7/25/13	Sun 9/15/13	21
23	Submit Final Work Plans to Army and MDNR	0 days	Sun 9/15/13	Sun 9/15/13	22
24	**Public Availability Session**	**53 days**	**Thu 7/25/13**	**Tue 10/8/13**	
25	Army Awards RI Field Work Option (Task 4)	0 days	Thu 7/25/13	Thu 7/25/13	
26	Army Prepares and Distributes Letters to Public Regarding Availability Sessic	52 days	Fri 7/26/13	Mon 10/7/13	25
27	Public Availability Session in St. Louis	1 day	Tue 10/8/13	Tue 10/8/13	26
28	**Remedial Investigation / Feasibility Study**	**570 days**	**Thu 7/25/13**	**Wed 9/30/15**	
29	**RI Field Work, Sample Analysis, Data Validation, Technical Memorandum Preparation**	**332 days**	**Thu 7/25/13**	**Fri 10/31/14**	
30	Army Awards RI Field Work Option (Task 4)	0 days	Thu 7/25/13	Thu 7/25/13	
31	Perform RI Field Work (Install and Sample Groundwater Wells, Perform First Round of Vapor Intrusion Assessments)	53 days	Wed 10/30/13	Fri 1/10/14	23,30,26FS+4 days
32	Perform Laboratory Analysis of Samples	30 edays	Fri 1/10/14	Sun 2/9/14	31
33	Perform Data Validation	10 days	Mon 2/10/14	Fri 2/21/14	32
34	Prepare Draft Technical Memoranda	20 days	Mon 2/24/14	Fri 3/21/14	33
35	Submit Draft Technical Memoranda to Army	0 days	Fri 3/21/14	Fri 3/21/14	34
36	Army Review of Draft Technical Memoranda	20 days	Mon 3/24/14	Fri 4/18/14	35
37	Submit Final Technical Memoranda to Army and MDNR	0 days	Fri 4/18/14	Fri 4/18/14	36
38	Perform RI Field Work (Perform Second Round of Vapor Intrusion Assessments)	20 days	Mon 3/31/14	Fri 4/25/14	31SS+150 edays
39	Perform Laboratory Analysis of Samples	30 edays	Fri 4/25/14	Sun 5/25/14	38
40	Perform Data Validation	10 days	Mon 5/26/14	Fri 6/6/14	39
41	Prepare Draft Technical Memoranda	20 days	Mon 6/9/14	Fri 7/4/14	40
42	Submit Draft Technical Memoranda to Army	0 days	Fri 7/4/14	Fri 7/4/14	41
43	Army Review of Draft Technical Memoranda	20 days	Mon 7/7/14	Fri 8/1/14	42
44	Submit Final Technical Memoranda to Army and MDNR	0 days	Fri 8/1/14	Fri 8/1/14	43
45	Perform RI Field Work (Perform Third Round of Vapor Intrusion Assessments)	20 days	Mon 6/30/14	Fri 7/25/14	38SS+90 edays
46	Perform Laboratory Analysis of Samples	30 edays	Fri 7/25/14	Sun 8/24/14	45
47	Perform Data Validation	10 days	Mon 8/25/14	Fri 9/5/14	46
48	Prepare Draft Technical Memoranda	20 days	Mon 9/8/14	Fri 10/3/14	47

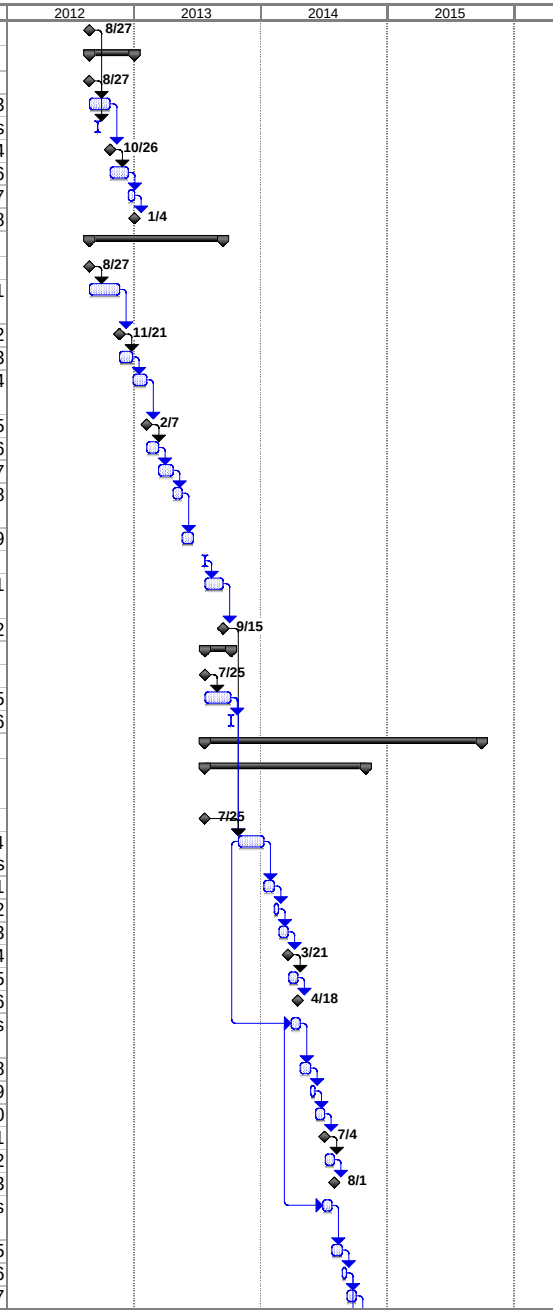
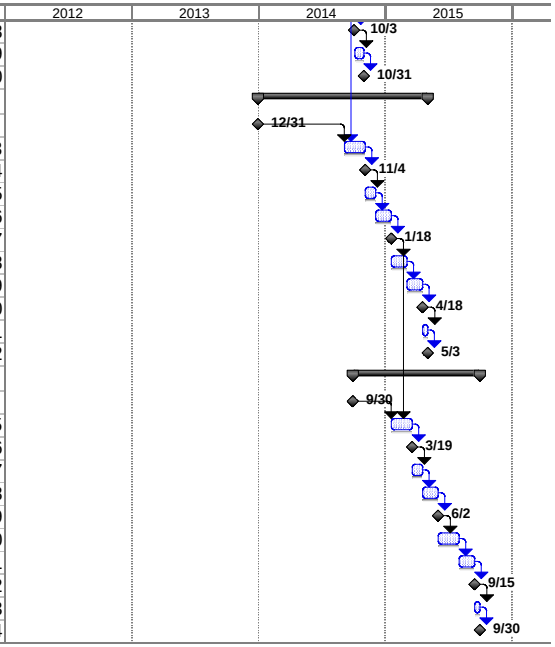
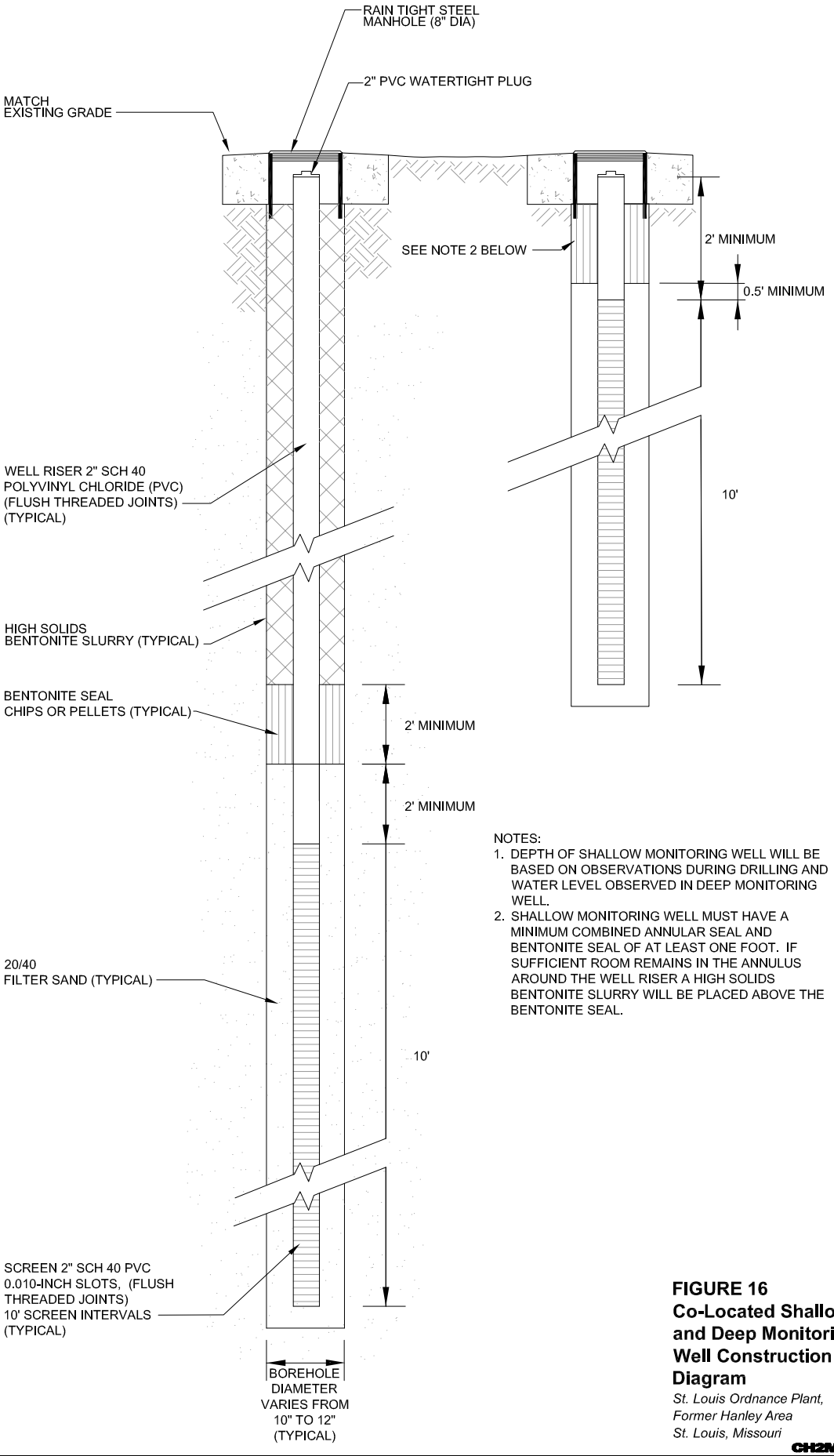


Figure 15
Project Schedule
Operable Unit 2 Remedial Investigation / Feasiblity Study
St. Louis Ordnance Plant, St. Louis, Missouri

ID	Task Name	Duration	Start	Finish	Predecessors
49	Submit Draft Technical Memoranda to Army	0 days	Fri 10/3/14	Fri 10/3/14	48
50	Army Review of Draft Technical Memoranda	20 days	Mon 10/6/14	Fri 10/31/14	49
51	Submit Final Technical Memoranda to Army and MDNR	0 days	Fri 10/31/14	Fri 10/31/14	50
52	**RI Report**	**349 days**	**Tue 12/31/13**	**Sun 5/3/15**	
53	Army Awards RI Report Option (Task 5)	0 days	Tue 12/31/13	Tue 12/31/13	
54	Prepare Draft RI Report	60 edays	Fri 9/5/14	Tue 11/4/14	47,53
55	Submit Draft RI Report for Army Review	0 days	Tue 11/4/14	Tue 11/4/14	54
56	Army Review of Draft RI Report	30 edays	Tue 11/4/14	Thu 12/4/14	55
57	Prepare Responses to Army Comments and Update Report	45 edays	Thu 12/4/14	Sun 1/18/15	56
58	Submit Draft Final RI Report to Army and MDNR	0 days	Sun 1/18/15	Sun 1/18/15	57
59	MDNR Review of Report	45 edays	Sun 1/18/15	Wed 3/4/15	58
60	Prepare Responses to MDNR Comments and Update RI Report	45 edays	Wed 3/4/15	Sat 4/18/15	59
61	Submit Final RI Report to Army and MDNR	0 days	Sat 4/18/15	Sat 4/18/15	60
62	MDNR Review of Final RI Report	15 edays	Sat 4/18/15	Sun 5/3/15	61
63	MDNR Approval of RI Report	0 days	Sun 5/3/15	Sun 5/3/15	62
64	**Feasibility Study (FS) Report**	**262 days**	**Tue 9/30/14**	**Wed 9/30/15**	
65	Army Awards FS Report Option (Task 6)	0 days	Tue 9/30/14	Tue 9/30/14	
66	Prepare Draft FS Report	60 edays	Sun 1/18/15	Thu 3/19/15	58,65
67	Submit Draft FS Report for Army Review	0 days	Thu 3/19/15	Thu 3/19/15	66
68	Army Review of Draft FS Report	30 edays	Thu 3/19/15	Sat 4/18/15	67
69	Prepare Responses to Army Comments and Update Report	45 edays	Sat 4/18/15	Tue 6/2/15	68
70	Submit Draft Final FS Report to Army and MDNR	0 days	Tue 6/2/15	Tue 6/2/15	69
71	MDNR Review of FS Report	60 edays	Tue 6/2/15	Sat 8/1/15	70
72	Prepare Responses to MDNR Comments and Update FS Report	45 edays	Sat 8/1/15	Tue 9/15/15	71
73	Submit Final FS Report to Army and MDNR	0 days	Tue 9/15/15	Tue 9/15/15	72
74	MDNR Review of Final FS Report	15 edays	Tue 9/15/15	Wed 9/30/15	73
75	MDNR Approval of FS Report	0 days	Wed 9/30/15	Wed 9/30/15	74





NOTES:

1. DEPTH OF SHALLOW MONITORING WELL WILL BE BASED ON OBSERVATIONS DURING DRILLING AND WATER LEVEL OBSERVED IN DEEP MONITORING WELL.
2. SHALLOW MONITORING WELL MUST HAVE A MINIMUM COMBINED ANNULAR SEAL AND BENTONITE SEAL OF AT LEAST ONE FOOT. IF SUFFICIENT ROOM REMAINS IN THE ANNULUS AROUND THE WELL RISER A HIGH SOLIDS BENTONITE SLURRY WILL BE PLACED ABOVE THE BENTONITE SEAL.

FIGURE 16
Co-Located Shallow and Deep Monitoring Well Construction Diagram
St. Louis Ordnance Plant, Former Hanley Area
St. Louis, Missouri

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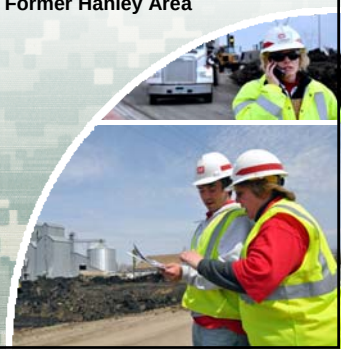
Appendix A
Meeting Summaries

Operable Unit 2 – Vapor Intrusion Pathway Strategy Meeting

St. Louis Ordnance Plant, Former Hanley Area

U.S. Corps of Engineers – Kansas City District
Bolling Federal Building, Room 438
Kansas City, Missouri
September 19, 2012



U.S. Army Environmental Command

88th Regional Support Command

US Army Corps of Engineers
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Proposed Meeting Agenda

- Introduction and Background
- Roles and Responsibilities
- Current Status of Operable Unit 2 (OU-2) Activities
- OU-2 Proposed Approach
- OU-2 Remedial Investigation / Feasibility Study (RI/FS) Schedule for FY13-FY14
- Conclusion/Wrap Up

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Introduction and Background

Began to Investigate Vapor Intrusion (VI) Pathway as part of the RI in 2008

- Indoor air (IA) sampled in one residence – Private Property 2 (PP-2)
  - Groundwater (GW) collected from temporary wells in residential areas
  - IA and outdoor air (OA) samples collected in March and May 2008, analyzed for 6 volatile organic compounds (VOCs)
  - No soil gas sampling outside residence due to tight, expansive clays
  - No VOCs exceeded current VI screening levels (SLs)
- Conclusion: Current VI pathway not significant at PP-2

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Introduction and Background

In 2010, Groundwater Concentrations Triggered Additional VI Assessments at Select Residential Properties

- In August 2010 pre-design GW investigation, GW samples were collected from monitoring well network around former Building 220
- 1,2-Dichloroethane (1,2-DCA) (23 µg/L) exceeded the Maximum Contaminant Level (MCL) of 5 µg/L in MW-107, located within 50 feet of PP-1

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Introduction and Background

Meeting Held on November 4, 2010 in Kansas City to Determine Path Forward

- Stakeholders agreed to perform VI assessment at PP-1 consisting of IA, OA, and subslab soil gas (SG) sampling
- VI sampling would be performed at PP-2, PP-3, and PP-4-contingent upon the results from PP-1

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Introduction and Background

Residential VI Assessments Performed in 2011 and 2012

- 2011 and 2012 – VI Assessments performed at the following residences:
  - PP-1 (May 2011, December 2011, and June 2012)
  - PP-2 (February 2012)
  - PP-3 (February 2012)
  - PP-17 (May 2011, December 2011)
- PP-17 was investigated at request of resident in response to public meeting notification letter sent by 88th Regional Support Command (RSC) in November 2010.
- A third attempt was made to sample PP-17. However, the resident could not commit.
- PP-4 could not be sampled due to lack of response to right-of-entry (ROE) request letters.

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Introduction and Background

Former Hanley Area Divided into Two Operable Units

- August 2011 – MDNR requested that Former Hanley Area be divided into two OUs in response to May 2011 VI assessment findings:
  - OU-1: Actions Addressing Contaminated Soil, Powder Well Sediment, and Groundwater Concerns
  - OU-2: Vapor Intrusion Pathway
- September 26, 2011: OU-1 Decision Document (DD) was signed by U.S. Army Environmental Command (USAEC)

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Introduction and Background

OU-1 Remedial Action Completed in May 2012

- Soil mixing with zero-valent iron (ZVI) completed in Plume A, groundwater contaminated primarily by tetrachloroethene (PCE) and trichloroethene (TCE).
- Land use controls (LUCs) established around Plume C – groundwater contaminated by carbon tetrachloride (CT)

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Roles and Responsibilities

Army Stakeholders

- U.S. Army Environmental Command (USAEC)
  - Provides management and oversight of cleanup activities
- U.S. Army Corps of Engineers – Kansas City District
  - Provides technical and contracting support to USAEC
- 88th Regional Support Command
  - Current property owner

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Roles and Responsibilities

Regulatory Stakeholders

- Missouri Department of Natural Resources (MDNR)
  - Lead regulatory agency
- Missouri Department of Health and Senior Services
  - Provides technical support to MDNR
- U.S. Environmental Protection Agency (USEPA), Region VII
  - Provides regulatory assistance to MDNR

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Current Status of OU-2 Activities

- U.S. Army Corps of Engineers-Kansas City District (USACE) has awarded contract to CH2M HILL to perform OU-2 RI/FS.
- Under OU-1, USACE is monitoring groundwater in existing monitoring wells on a quarterly basis.
  - Groundwater analytical results will be used in OU-2 RI/FS process.

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Current Status of OU-2 Activities

Status of Residences Contacted / Sampled to date:

- PP-1: Analytical results recently validated. Draft report is undergoing Army review.
- PP-2: Further assessment recommended.
- PP-3: Further assessment recommended.
- PP-4: ROE not granted. No further action planned at this time.
- PP-17: Further assessment was scheduled for June 2012, but resident could not commit to a time for the sampling to take place. Army asked resident to request a time for Army to perform assessment. No response from residence to date.

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Current Status of OU-2 Activities

May 11, 2012 letter from MDNR to USACE

- Requested opportunity to work with Army to revise work plans and develop a decision matrix to determine the follow-on actions based on investigation findings.
- Recommended sampling at least 7 homes on Stratford and Henner Avenues
- Recommended further investigation of potential VI from onsite CT plume to nearby Job Corps facility
- Recommended groundwater investigation to delineate the leading edge of the groundwater plume(s).

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Current Status of OU-2 Activities

- Recent inquiry to MDNR by the National Association for the Advancement of Colored People (NAACP).
- Input provided during today's meeting will be incorporated into a draft OU-2 work plan that will be submitted for Army review. After Army comments are incorporated, the draft final work plan will be submitted for MDNR and USEPA review.

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OU-2 Proposed Approach

- Investigation Objectives
- Chemicals of Potential Concern
- Sample Collection / Laboratory Analysis
- Screening Levels
- Investigation Approach
  - Proposed Groundwater Monitoring Well Locations
  - Proposed Residences for Initial VI Assessments
- Investigation Challenges
- Risk Assessment Approach
- Deliverables

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Investigation Objectives

- Determine whether VI of site-related VOCs is occurring and is significant at off-site residences.
- Determine whether VI of site-related VOCs could potentially occur to a significant extent in the future at off-site residences.
- Maintain proactive communication and responsiveness to the public throughout the OU-2 RI/FS.
- Obtain sufficient data during RI to develop remedial alternatives during the FS.
- Develop a decision matrix to determine next steps.

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Investigation Objective #1

Determine whether VI of site-related VOCs is occurring and is significant at off-site residences.

- "Occurrence" - assessed by evaluating multiple lines of evidence (e.g., comparison of VOC concentrations in IA, OA, SG, and GW; VOC background evaluation).
- "Site-related" – based on assessment of possible pathways from the former Hanley Area to the residence; also based on comparison among IA, OA, SG, and GW concentrations.
- "Significance" – based on comparisons with risk-based screening levels and human health risk assessment (HHRA) of site-related VOCs in IA.

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Investigation Objective #2

Determine whether VI of site-related VOCs could potentially occur to a significant extent in the future at off-site residences.

- "Site-related" – based on assessment of possible pathways from the former Hanley Area to the residence; also based on comparison among IA, OA, SG, and GW concentrations.
- "Significance" – based on comparisons with risk-based screening levels and HHRA of site-related VOC concentrations in SG, (indicator of potential future IA).

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Investigation Objective #3

Maintain proactive communication and responsiveness to the public throughout the OU-2 RI/FS.

- Conduct a public availability session prior to the RI.
- Clearly explain investigation objectives and scope to homeowners / residents during initial site visits.
- Promptly issue reports summarizing VI assessment findings to homeowner / residents.
- Clearly explain VI assessment findings to the homeowner / resident and recommendations based on the findings.

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Investigation Objective #4

Obtain sufficient data during RI to develop remedial alternatives during the FS.

- Develop FS alternatives based on:
  - HHRA findings
  - Applicable VI guidance
  - Applicable or relevant and appropriate requirements (ARARs)
- Develop alternatives that are effective, implementable, and maintainable.
- Develop alternatives that include an exit strategy.

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Investigation Objective #5

Develop a decision matrix to determine next steps.

- Decision matrix should clearly spell out what actions are to be taken and when the actions will occur based upon the data collected.
- Possible follow-on actions include:
  - additional sampling
  - vapor mitigation
  - expanding sampling population
  - no action

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Chemicals Selected for Analysis

- VOCs that exceeded the historic drinking water USEPA 6 Medium-Specific Screening Levels (MSSLs) during the OU-1 RI.
  - MSSLs were subsequently compared with and determined to be lower than USEPA VI SLs
- Methylene chloride (degradation product of CT) was added at MDNR's request during OU-1 FS phase.

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Chemicals Selected for Analysis

Benzene	Naphthalene
CT	PCE
Chloroform	TCE
1,2-DCA	1,1,2-Trichloroethane (1,1,2-TCA)
cis-1,2-Dichloroethene (DCE)	1,1,1,2-Tetrachloroethane (TeCA)
trans-1,2-DCE	1,1,2,2-TeCA
Methylene chloride	Vinyl chloride

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Sample Collection / Laboratory Analysis

Sample Collection Methods

- IA, OA, SG - 24-hour samples in 6-liter, individually-certified canisters
- GW - low-flow sample collection

Laboratory Analytical Methods

- IA, OA, SG - TO-15, Selective Ion Mode (SIM)
- GW - SW846 8260B

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VI Screening Levels

Groundwater

- In March 2012, USEPA released a VI SL calculator that provides conservative default VI screening levels.
  - Assumes an attenuation factor of 0.001 for GW to IA, an excess lifetime cancer risk (ELCR) of 1×10^{-6}, and hazard quotient of 1.0 for noncarcinogens.

Indoor Air / Outdoor Air

- USEPA Regional Screening Levels (RSLs) for Residential Air. The most recently available screening levels at the time of report preparation will be used.

Subslab Soil Gas

- Residential Soil gas-to-indoor air screening levels from USEPA VI SL calculator
  - Assumes default soil gas-to-indoor air attenuation factor of 0.1. The most recently available screening levels at the time of report preparation will be used.

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Investigation Approach

Install and Sample Additional Groundwater Monitoring Wells

- Further investigate potential VI from onsite CT plume to nearby Job Corps facility
- Refine understanding of groundwater gradient and flow direction
- Determine whether shallow GW near (within 100 feet) or beneath residences has been impacted by the site at levels above conservative regulatory-based VI SLs
  - If so, then perform VI assessment at the nearby residences (if not already selected for VI assessment) to determine if VI of site-related VOCs from GW is occurring and is significant in the off-site residences

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Investigation Approach

Concurrent with the Groundwater Investigation, Perform VI Assessments at Select Residences

- Perform another round of VI assessments at residences where Army recommended follow-on VI assessments (PP-2, PP-3, and PP-17)
- Sample at select other homes (PP-4) if access granted – home is vacant and directly across from Former Hanley Area
- Target to sample each residence a minimum of 3 times (including sampling events already performed)

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Investigation Approach

Select Additional Residences for VI Assessments

- Sample homes within 100 feet of VI SL exceedances in GW
- Sample residences adjacent to those previously sampled where possible site-related chemicals are found in sub-slab SG above SLs.
- Potentially sample residences where concerns are raised by residents / property owners – evaluate on a case-by-case basis.

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Investigation Approach

Perform Multiple Rounds of VI Assessments at each Residence

- Goal is to complete 3 rounds of VI sampling at each residence prior to issuing the RI report.
- Each round will be separated by at least 3 months (i.e., at least quarterly).
- Objective is to perform VI assessments in different seasons to assess temporal variability.

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Investigation Challenges

Difficulty in obtaining right of entry (ROE) or access to property after ROE has been signed

- Three consecutive days of access required for first VI assessment (probe installation; canister deployment / leak check; canister retrieval; building survey)
- Two consecutive days of access required for subsequent VI assessments
- No ROE granted for PP-4 (no response to USACE letters)
- Inability of PP-17 residents to commit to a time for allowing the Army to perform VI assessment round #3 in June 2012.

Possible interference due to background chemical sources

- Initially, conduct building survey/chemical inventory

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Investigation Challenges

Rights of Entry

- Property owners identified through search of St. Louis City Assessors online database.
- USACE sends first letter with right-of-entry (ROE) agreement, requests response within 30 days.
- If no response, USACE sends second letter with ROE agreement, requests response within 30 days.
- If no response, ROE is considered refused and investigation at that residence is suspended.

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Investigation Challenges

Possible Interference due to Background Chemical Sources

- Resident is requested to remove chemicals potentially containing target analytes 24 hours prior to sampling
  - Some residents have complied with this request during previous VI assessments.
  - Sometimes this is not feasible – e.g., too numerous or nowhere to temporarily store chemicals.
  - Army does not intend to provide temporary outdoor storage for storing household products while the VI assessments are in progress.
- Perform detailed chemical inventory of chemicals that remain in house when VI assessment is performed

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Risk Assessment Approach

- HHRA will evaluate potential current and future human health risks to residents
- Conducted in accordance with *Risk Assessment Guidance for Superfund (RAGS)*
- Risk calculations will be performed for the new residences sampled and the 4 residences sampled in 2011 and 2012
- Risk assessment findings will be presented for each residence in the OU-2 RI report

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Risk Assessment Approach

- Site-related chemicals of potential concern (COPCs) will be evaluated for each residence
  - COPCs are chemical concentrations that exceed SLs and may be due to VI based on the lines of evidence presented in the VI assessment technical memoranda (TMs)
  - Maximum concentration of each COPC from multiple rounds of sampling will be used in HHRA
- Current risk calculated from IA site-related COPC concentrations
- Potential future risk calculated from site-related SG COPC concentrations

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Risk Assessment Approach

- Cumulative cancer risk and target-organ specific noncancer hazard indices (HI) will be estimated for site-related COPCs for adult and child residents
- Individual and cumulative estimated cancer risks and HIs will be compared to USEPA and state targets identified in the work plan
- Chemicals exceeding thresholds will be identified as chemicals of concern (COCs)

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Deliverables

Work Plans

- Project Management Plan, Quality Control Plan (submitted to Army only)
- UFP-QAPP, Field Sampling Plan, Health and Safety Plan

Vapor Intrusion Technical Memoranda (TMs)

- One TM for each round of VI assessment for each residence
- Similar in format and content as previously submitted documents
- Final VI TM will identify site-related COPCs in IA and SG that warrant evaluation in the HHRA

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Deliverables

Remedial Investigation Report

- The RI report will consider new data (2013 and beyond), historic VI assessment samples collected between 2008 and 2012, and historic groundwater samples collected from permanent monitoring wells between 2005 and 2012.
- RI will include one HHRA for each residence where VI assessments were performed.

Feasibility Study Report

- FS report will present general remedial alternatives applicable to residences where site-related COCs exceed preliminary remediation goals.

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OU-2 RI/FS Schedule for FY 2013 and 2014

- USACE will award optional tasks on or before the following dates:
  - Optional Task 4 (Conduct RI) – Fiscal Year (FY) 13 3rd Quarter (no later than June 30, 2013)
  - Optional Task 5 (Prepare RI Report) – FY 14 1st Quarter (no later than December 31, 2013)
  - Optional Task 6 (Prepare FS Report) – FY 14 4th Quarter (no later than September 30, 2014)

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Conclusion / Wrap-up

- Review Action Items

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Operable Unit 2 Strategy Meeting for the St. Louis Ordnance Plant, Former Hanley Area, September 19, 2012

PREPARED FOR:

Jonathan Harrington – U.S. Army Environmental Command (USAEC)
Dave Moore – 88th Regional Support Command (RSC)
Barry McFarland – 88th RSC Contractor
Josephine Newton-Lund – U.S. Army Corps of Engineers (USACE)-Kansas City District
Jason Leibbert –USACE-Kansas City District
Brad Brink –USACE-Kansas City District
Krista McGowan –USACE-Kansas City District
Jacqy Frazier –USACE-Kansas City District
Dave Crawford –USACE-Kansas City District
Dan Hearnen –USACE-Kansas City District
Jim Harris – Missouri Department of Natural Resources (MDNR)
Michelle Hartmann – Missouri Department of Health and Senior Services (MDHSS)
Matt Jefferson – U.S. Environmental Protection Agency (USEPA) – Region VII
Bill Pedicino – USEPA – Region VII
Robin Rodriguez – The Chamberlain Group (USEPA contractor via telephone)
Chris English – CH2M HILL
Tony Swierczek – CH2M HILL
Loren Lund – CH2M HILL

PREPARED BY: CH2M HILL

DATE: September 24, 2012

A meeting was held on September 19, 2012 at the USACE-Kansas City District to discuss the vapor intrusion (VI) pathway strategy for Operable Unit 2 (OU-2) at the St. Louis Ordnance Plant, former Hanley Area. The agenda presented during the meeting is provided below:

- Introduction and Background
- Roles and Responsibilities
- Current Status of OU-2 Activities
- OU-2 Proposed Approach
- OU-2 Remedial Investigation/Feasibility Study (RI/FS) Schedule for FY13-FY14
- Conclusion/Wrap Up

The attendee list, presentation slides, meeting handouts, and a working figure showing the proposed RI approach for OU-2 are attached to this meeting summary. Hard copies of the presentation slides and meeting handouts (VI chronology, community outreach chronology, and four figures showing current site features and recent analytical results) were also provided to the attendees before the meeting. The working figure was projected on the screen and updated during the meeting based on feedback provided by the meeting participants.

Introductions and Background

Following introductions, Josephine Newton-Lund of the USACE-Kansas City District briefly discussed the site background, roles and responsibilities, and the current status of OU-2 activities, as it relates to the VI pathway. Please refer to the attached presentation slides for the background information discussed.

Roles and Responsibilities

Please refer to the presentation slides regarding project roles and responsibilities that were discussed during the meeting.

Current Status of OU-2 Activities

Ms. Newton-Lund noted that one round of long-term management (LTM) groundwater monitoring, as part of the OU-1 remedy, was completed in July 2012 by CH2M HILL, and the subsequent rounds will be completed by USACE-Kansas City District. The next quarterly LTM groundwater monitoring event is scheduled for November 2012. Groundwater results obtained during LTM will be used in the OU-2 RI/FS process.

Please refer to the presentation slides for additional details regarding the current status of OU-2 activities.

OU-2 Proposed Approach

Chris English of CH2M HILL facilitated a discussion on the proposed RI/FS approach for OU-2. The following items were discussed:

- Investigation Objectives
- Chemicals of Potential Concern
- Sample Collection/Laboratory Analysis
- Screening Levels
- Investigation Approach
    - Proposed Groundwater Monitoring Well Locations
    - Proposed Residences for Initial VI Assessments
- Investigation Challenges
- Risk Assessment Approach
- Deliverables

Before the discussing investigation objectives, Mr. English noted that the Army was considering two public availability sessions to inform the public of recent progress related to OU-1 and upcoming activities related to OU-2. The Army was interested in an availability session in November 2012 at the Job Corps facility, located west of the St. Louis Ordnance Plant. The first session would be held to update the stakeholders on the current status of OU-1 activities, with a brief discussion on future OU-2 activities. A second session would be held in April 2013 after the OU-2 work plans were completed. It would provide more detail concerning upcoming OU-2 activities. Because of time constraints, the meeting participants discussed preparation of an updated fact sheet and letter to the public in lieu of the November 2012 public availability session. This option will be will be further discussed among the Army team. If the letter and fact sheet are chosen as the communication tool in November 2012, USAEC will work with Ramona Huckstep of MDNR to prepare the information. Ms. Newton-Lund will contact Rosalind Portis of the Job Corps to request holding a future public availability session at the Job Corps facility.

Investigation Objectives

The following investigation objectives were presented for OU-2:

1. Determine whether VI of site-related VOCs is occurring and is significant at off-site residences.
2. Determine whether VI of site-related VOCs could potentially occur to a significant extent in the future at off-site residences.
3. Maintain proactive communication and responsiveness to the public throughout the OU-2 RI/FS.
4. Obtain sufficient data during RI to develop remedial alternatives during the FS.
5. Develop a decision matrix to determine next steps.

Rationale and details regarding each objective are provided in the presentation slides.

Mr. English highlighted the importance of Investigation Objective 3, given that a resident recently told the National Association for the Advancement of Colored People (NAACP) that the Army could have been timelier in communicating the results of the VI assessment at their residence. During the OU-2 RI, the Army will strive to submit a VI technical memorandum within 6 weeks after conducting each VI assessment.

To summarize community outreach that has occurred since 2004, Mr. English referred to a handout detailing the chronology of community outreach activities. He also referenced a handout summarizing VI assessments that have been completed to date. These handouts demonstrate the Army's commitment to community outreach and responsiveness in assessing the VI pathway. Ms. Newton-Lund noted that the Community Involvement Plan prepared in 2008 will be updated and will include the NAACP as a stakeholder. The Army will mail letters notifying the community of the Army's plan to update the CIP.

During the presentation of Investigation Objective 4 (Obtain sufficient data during RI to develop remedial alternatives during the FS), the meeting participants discussed the upcoming revisions to USEPA's VI guidance document (currently scheduled for release in November 2012). Bill Pedicino of USEPA noted that the November 2012 release date may slip because of policy issues. For instance, USEPA Regions III and IV have differing opinions over the appropriate screening level for the effects of trichloroethene (TCE) on fetal heart development. Dave Crawford of the USACE-Kansas City District added that the debate concerns the non-cancer screening level and not the cancer-causing screening level. Loren Lund of CH2M HILL commented that, even at the screening levels currently in debate by the different USEPA regions, the low TCE concentrations in indoor air observed at the residences downgradient of the former Hanley Area are not expected to exceed either screening level in indoor air.

If the revised VI guidance release is delayed, the Army will still proceed with assessing the VI pathway. The Army will incorporate the VI guidance into the RI/FS approach to the degree practicable once the guidance is released.

Chemicals Selected for Analysis

The Army intends to use the same chemical reporting list of 14 VOCs that was used during previous VI assessments. These VOCs exceeded historic drinking water USEPA Regional 6 Medium Specific Screening Levels (MSSLs) during the OU-1 RI. The MSSLs were subsequently compared with and determined to be lower than USEPA's VI SLs discussed later in this summary. The reporting list is provided below:

- Benzene
- Carbon tetrachloride
- Chloroform
- 1,2-Dichloroethane (1,2-DCA)
- *cis*-1,2-Dichloroethene (*cis*-1,2-DCE)
- trans-1,2-Dichloroethene (*trans*-1,2-DCE)
- Methylene chloride
- Naphthalene
- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- 1,1,2-Trichloroethane (1,1,2-TCA)
- 1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA)
- 1,1,2,2- Tetrachloroethane (1,1,2,2-TeCA)
- Vinyl chloride

The chemical 1,1,1-2-TeCAis not included in the TO-15 analytical method used for indoor air, outdoor air, and subslab soil gas samples. Mr. English noted that 1,1,1,2-TeCA has only been measured above the MSSL in one monitoring well (MW-111), and that area was treated via soil mixing with zero-valent iron during the OU-1 remedial action. The presence of 1,1,1,2-TeCA will be monitored in groundwater during the OU-2 RI.

Sample Collection / Laboratory Analysis

The Army plans to use similar sample collection and laboratory analytical methods employed during previous VI assessments. Indoor air, outdoor air, and subslab soil gas samples will be collected over a 24-hour period using 6-liter, individually-certified canisters and analyzed for VOCs via TO-15, Selective Ion Mode (SIM). Groundwater samples will be collected using low-flow methods and analyzed for VOCs via SW846 Method 8260 B.

A brief discussion was held among Mr. Pedicino and Jason Leibbert of the USACE-Kansas City District concerning various soil gas sampling devices. Mr. Pedicino stated that he is using sorbent tubes to collect soil gas outside of structures. As opposed to the 24-hour canister sample collection that the Army is using to collect subslab soil gas

samples, USEPA is using a 1-hour sample collection time using Tedlar bags and a mobile lab to get results as soon as possible. Additionally, USEPA is using plastic barbed fittings installed in the slab to collect subslab soil gas samples because the location can be sampled quickly (it does not require a mortar/cement seal), removed quickly, and patched within the same day. Michelle Hartman of MDHSSS stated that, even though subslab samples can be collected relatively quickly, indoor air samples should be collected over a 24-hour sample period and should be collected concurrently with subslab soil gas samples to assess current exposure (e.g., indoor air) and potential future exposure (e.g., subslab soil gas). Dr. Lund added that shorter indoor air sample collection times result in higher variability. He also commented that passive samplers, such as sorbent tubes, are not ideal for the subslab conditions observed at the offsite residences (soil/clay directly beneath the slab). Passive samplers tend to trap fresh air and not vapors when installed in tight lithology. Mr. Pedicino has used a pump in combination with passive samplers to minimize the amount of fresh air entrained in the passive sampler.

Mr. Pedicino inquired about the use of the TO-15 SIM analytical method for subslab soil gas samples. He was concerned that the sensitive laboratory instrumentation could be damaged by using this low-level test method. Mr. English noted that the laboratory was made aware of the potential for higher subslab soil gas concentrations before moving forward with SIM analysis. Dr. Lund commented that the SIM test method reduces uncertainty because this method is able to detect low-level concentrations below screening levels.

Vapor Intrusion Screening Levels

The Army intends to use the following screening levels during the OU-2 RI.

Groundwater

The Army will use the most current VI screening level calculator (VISL) to develop groundwater screening levels. The calculator was released by USEPA in March 2012 to provide conservative default VI screening levels. It assumes an attenuation factor of 0.001 for groundwater to indoor air, an excess lifetime cancer risk (ELCR) of 1×10^{-6}, and hazard quotient of 1.0 for noncarcinogens.

Indoor Air / Outdoor Air

The most recently available USEPA Regional Screening Levels (RSLs) for Residential Air at the time of report preparation will be used.

Subslab Soil Gas

Residential Soil gas-to-indoor air screening levels will be identified using the USEPA VISL calculator. A default soil gas-to-indoor air attenuation factor of 0.1 is assumed. The most recently available screening levels at the time of report preparation will be used.

Mr. English noted that the Missouri Risk-Based Corrective Action (MRBCA) Risk-Based Target Levels (RBTLs) for resident air will no longer be a screening level source for indoor air and subslab soil gas, as was done during the previous VI assessments. Rather, the USEPA Regional Screening Level for resident air and the residential soil gas-to-indoor air screening levels from the VI screening level (VISL) calculator will be used because these values are updated more frequently. Additionally, the calculated VISLs for groundwater-to-indoor air will be used for groundwater.

Because screening levels are updated on a routine basis, Mr. Crawford recommended including appropriate documentation in the VI assessment technical memoranda to demonstrate how the screening levels were derived. A copy of the VISL output would suffice.

Investigation Approach

The meeting participants discussed the following investigation approach:

- Install and sample additional groundwater monitoring wells.
- Concurrent with the groundwater investigation, perform VI assessments at select residences.

- Select additional residences for VI assessments based on groundwater and initial VI assessment findings.
- Perform multiple rounds of VI assessments at each residence.

The meeting participants used an on-board review format to refine the investigation approach by revising a working figure of proposed sample locations. A final version of the working figure is provided as an attachment to this meeting summary.

A phased RI approach will begin by assessing groundwater conditions. Mr. Pedicino noted that the utility corridors could act as potential vapor migration routes if they are not submerged. Mr. English noted that, based on the shallow groundwater depths at lower elevations of the former Hanley Area and along Stratford Avenue, the utility corridors may be in groundwater. Dr. Lund noted the preferential pathways (e.g., utility corridors) will be further investigated during the RI. Based on the locations of utilities near residences that have been investigated to date, utility corridors currently do not appear to be a preferential pathway for VI, but this will be assessed further during the OU-2 RI. Mr. English noted that public and private utilities will be located and recorded using a Global Positioning System (GPS) device for inclusion on subsequent figures.

Concurrent with the groundwater investigation described above, the Army intends to conduct VI assessments at Private Properties 2 through 5 (PP-2 through PP-5), located along Stratford Avenue. Dr. Lund noted that historic groundwater concentrations in select offsite monitoring wells exceeded VISLs during at least one sampling event; this prompted the need for VI assessments at PP-1 through PP-4. The Army has completed at least one VI assessment at PP-1 through PP-3; the Army was unable to conduct a VI assessment at PP-4 because the owner did not respond to the Army's right-of-entry (ROE) requests in 2012. The VI pathway will be assessed by performing multiple rounds of VI assessments at PP-2, 3, and 4, subject to ROE acceptance by the property owners. Because of the historic groundwater concentrations at monitoring well MW-109 (TCE slightly exceeded the VISL of 1.1 micrograms per liter [µg/L] between April 2007 and December 2011), the Army also intends to conduct a VI assessment at PP-5, located within 50 feet of MW-109.

At PP-1, CH2M HILL has recommended no further near-term VI assessments, based on three VI assessments completed there between May 2011 and June 2012. The Army is currently reviewing the technical memorandum for the June 2012 VI assessment.

The meeting participants discussed the location of permanent monitoring wells to be installed during the OU-2 RI. Mr. English presented the proposed locations on the working figure. The Army intends to install wells onsite and along Stratford Avenue, using a "follow the evidence" approach for selecting additional monitoring well locations, if necessary, based on results from the initially-installed monitoring wells.

Permanent monitoring wells will be installed along Stratford Avenue (if feasible based on presence/absence of underground utilities) and at the former Hanley Area, west of MW-118. The wells along Stratford Avenue will serve to refine the understanding of VOC contamination and groundwater flow direction and gradient north and northwest of the former Hanley Area. The onsite well location west of MW-118 will assess the potential for VI onto Job Corps property.

From a VI perspective, groundwater VOC concentrations at the water table are of greatest interest because they indicate potential volatilization of chemicals from groundwater to soil gas. Based on the lithology observed in the subsurface (tight clays with discontinuous lenses for coarser grained, more permeable materials) and the low groundwater recharge rate observed in the overburden soils, the depth to groundwater north of the former Hanley Area is uncertain. For this reason, the meeting participants agreed that nested monitoring wells would be installed to increase the likelihood that one of the nested wells would intercept the water table. The deep well will terminate at the overburden / weathered shale contact, and the shallow well will be screened at higher depth interval such that the screened intervals of the shallow and deep wells do not overlap. Existing monitoring wells MW-107, MW-108, and MW-109 terminate at the overburden/weathered shale contact, and their well screens are fully submerged. Therefore, shallow wells will be installed next to each of these existing wells to assess groundwater conditions at the water table. The remaining proposed well locations will utilize nested well pairs.

Construction details regarding the monitoring wells were not discussed during the meeting; this information will be provided in a forthcoming work plan.

Mr. Pedicino asked whether the Army had considered installing vapor mitigation systems at the residences instead of completing VI assessments. Ms. Newton-Lund explained that this approach would not be acceptable to the Army's legal counsel. Mr. English also noted that a clear exit strategy would need to be in place to determine when/whether the systems could be removed. Dr. Lund added that additional investigation would be needed to demonstrate that VI is no longer a concern.

Mr. Pedicino asked about conducting in-home VI assessments further west of PP-5. Mr. English responded that the "follow the evidence" approach (e.g., assessing groundwater results and the VI assessment results in PP-5) would determine whether VI assessments would be performed at residences west of PP-5.

Jim Harris of MDNR recommended installing a nested well pair further west of the originally-proposed monitoring wells along Stratford Avenue. The Army agreed to install this additional nested well pair under the condition that their analytical results would not necessarily trigger the need for additional monitoring wells or VI assessments; that determination would be based on the results from the nested pair and others further east (closer to the former Hanley Area).

Investigation Challenges

The meeting participants discussed two primary challenges during the meeting:

- difficulty in obtaining ROE or access to the property after ROE has been signed; and
- possible interference due to background chemical sources.

During the discussion of challenges that may be encountered during the RI for OU-2, Ms. Newton-Lund asked whether a healthy homes survey was conducted at PP-17. Ms. Hartman of MDHSS stated that several attempts were made to schedule a visit with the residents at PP-17, with no response received. MDHSS currently does not plan on pursuing further attempts to conduct a healthy homes survey at PP-17.

Challenges concerning ROE requests were discussed. Dr. Lund noted that, in general, 20 to 25 percent of ROE requests are typically refused. Ms. Newton-Lund will speak with the Army's Real Estate Division about including a "Decline" box, along with language concerning the ramifications of a refusal, in the ROE request. Ms. Hartman requested that the Army provide the regulators with an example ROE request.

Mr. English noted that each resident would be asked to remove household chemicals from their residence at least 24 hours before each VI assessment. Mr. Crawford asked whether 24 hours was considered a sufficient timeframe to allow household chemical concentrations to dissipate after the sources were removed. Dr. Lund responded that, based on the air exchange rate observed at other study sites, 24 hours was an adequate timeframe.

Risk Assessment Approach

The meeting participants discussed the human health risk assessment approach (HHRA) for OU-2. Please refer to the presentation slides for details on the items discussed.

Using appropriate lines of evidence, chemical concentrations in indoor air and subslab soil gas will be evaluated to determine whether they are potentially site-related. Chemicals of potential concern (COPCs) are chemicals that are deemed to be potentially site-related and have concentrations exceeding screening levels. COPCs will be carried through the HHRA. Krista McGowan of the USACE-Kansas City District recommended that the forthcoming work plan use terminology consistent with Department of Defense and USEPA guidance. Dr. McGowan noted that, once the HHRA is performed, the more appropriate term for chemicals that pose unacceptable risk is "potential chemicals of concern". A "chemical of concern" (COC) is a term used in the decision document.

Ms. Hartman recommended that the decision matrix for OU-2 include short-term and long-term actions. For example, immediate action or notifications may be warranted if chemical concentrations at a particular residence are substantially elevated above screening levels. Action levels for immediate actions or notifications should be included in the decision matrix in the forthcoming OU-2 work plan.

Deliverables

The primary deliverables during the OU-2 RI/FS will consist of the following:

- work plans
- VI technical memoranda
- RI report
- FS report

Please refer to the presentation slides for additional details regarding each of these deliverables.

OU-2 RI/FS Schedule for FY 2013 and 2014

The OU-2 RI/FS schedule was discussed. The draft OU-2 work plan will be submitted for Army review this fall. Following Army review, the draft OU-2 work plan will be submitted to the regulators for review. Following finalization of the work plan, the anticipated funding schedule for follow-on activities is as follows:

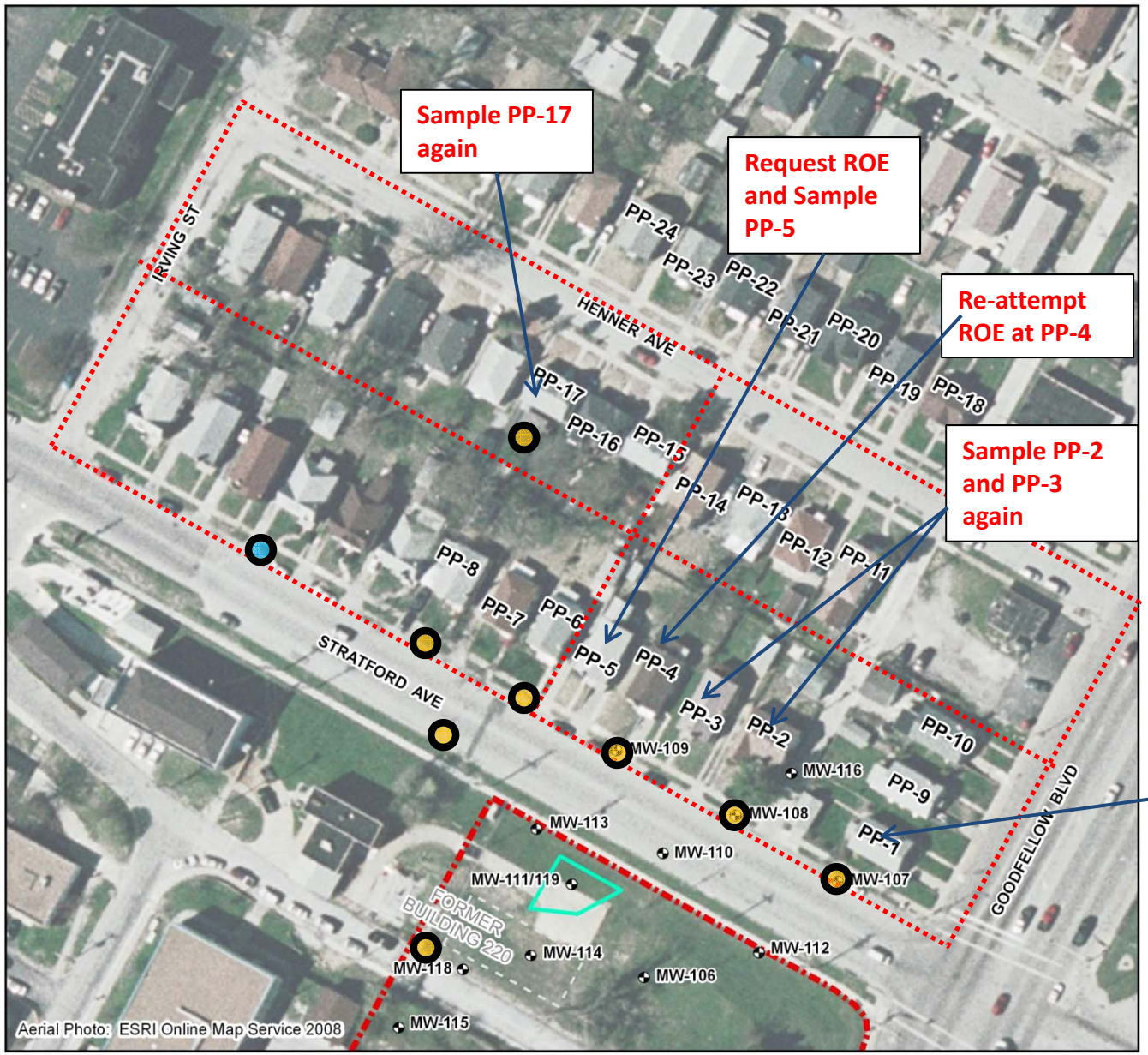
- Optional Task 4 (Conduct RI) – Fiscal Year (FY) 13 3rd Quarter (no later than June 30, 2013)
- Optional Task 5 (Prepare RI Report) – FY 14 1st Quarter (no later than December 31, 2013)
- Optional Task 6 (Prepare FS Report) – FY 14 4th Quarter (no later than September 30, 2014)

Conclusion / Wrap-up

Following the presentation, the meeting participants discussed a day care facility located north of the former Hanley Area, at the corner of Henner Avenue and Goodfellow Boulevard. Ms. Hartman noted that the day care facility should be investigated because it lies near the site. Dr. Lund noted that VI assessment findings from PP-1, located between the former Hanley Area and the day facility, do not suggest that an investigation is warranted. Regardless, Ms. Hartman noted that stated that it is policy to investigate buildings that are used as day care facilities when environmental release sites are located nearby. Mr. Pedicino stated that USEPA would sample the day care facility if the Army does not agree to sample it. Ms. Newton-Lund suggested that MDHSS prepare a formal request to the Army to sample the day care facility. Jonathan Harrington of USAEC will discuss this topic with USAEC management.

Action Items

- The Army will determine whether the November 2012 community outreach effort will be a public availability session or an updated fact sheet and letter to the public.
- Ms. Newton-Lund will contact Rosalind Portis of the Job Corps to request holding a future public availability sessions at the Job Corps facility.
- CH2M HILL will prepare an OU-2 work plan that incorporates the discussions held during the OU-2 strategy meeting.
- Mr. Harrington will discuss the possible investigation of a nearby day care facility with USAEC management.



= Proposed Monitoring Well

ROE = Right of Entry

PP = Private Property

LEGEND
- Site Boundary
- Soil Mixing Treatment Area
- Former Building
- Monitoring Well

N

0 50 100 Feet

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FIGURE 2
RESIDENTIAL PROPERTIES ADJACENT TO FORMER HANLEY AREA
St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

CH2MHILL

Operable Unit 2 - Vapor Intrusion Pathway Strategy Meeting

Former Hanley Area, St. Louis Ordnance Plant

September 19, 2012

Bolling Federal Building - Room 438, Kansas City, Missouri

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Appendix B
Laboratory Standard Operating Procedures

EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

ORGANICS: SOP 202 **REVISION #: 25** **EFFECTIVE DATE: 20120926**

GC/MS VOLATILES BY EPA METHOD E624 & SW846 METHOD 8260B INCLUDING APPENDIX IX COMPOUNDS

APPROVALS:

Lab Director: _____ Date: 09/26/2012

Data Quality Manager: _____ Date: 09/26/2012

Section Supervisor: _____ Date: 09/26/2012

Changes Summary

Revision 25, 09/26/12

- All references to Target have been updated to reflect Chemstation for data processing.
- Library reference has been updated to NIST98.L.
- Data review checklist has been updated to include a place for the sample number used to recalculate the concentration from raw area counts all the way to the final LIMS concentration.
- References to LCS have been updated to reflect BS.

Revision 24, 09/13/11

- This SOP is an update from Revision 23 dated 09/09/10.
- Section 9 has been updated with column and concentrator information.
- Section 10 has been updated with current standards mixtures.
- Section 13.1 has been updated to reflect calibration curve for analytes and surrogates.
- References to QSM 4.1 have been updated to QSM 4.2.

Revision 23, 09/09/10

- This SOP is an update from Revision 22 dated 09/30/09.
- Tables 1 and 2 have been updated with appropriate reference updates.
- Tables 5-7 have been added.

Revision 22, 9/30/09

- The SOP is an update from Revision 21 dated 09/11/08
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.2, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

Table of Contents

1. Identification of the Test Method

1.1 This SOP is compliant with methods – EPA Method 624 and SW-846 Method 8260B

2. Applicable Matrix or Matrices

2.1 This SOP is applicable to – The analysis of volatile organic compounds in a variety of matrices including but not limited to soils, sediments, ground and surface waters, aqueous sludge, oily wastes, etc.

3. Detection Limit: See **Table 1** of this SOP.

4. Scope of Application, Including components to be Analyzed

4.1 This SOP is based primarily on SW-846 Method 8260B. Methods SW-846 Method 8000B; *Federal Register* Method 624; and CLP Method for Volatiles have also been used in the development of this SOP. The analyses by these various methods are clearly defined in the respective regulatory manuals. A good understanding of these different methods is essential to the performance of each method. Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. When applicable, surrogate and Internal Standard Analytes are listed and indicated as such within this table.

5. Summary of the Test Method

5.1 After sample preparation, the sample is introduced into the GC/MS generally using purge and trap but sometimes using direct injection (see SW-846 Methods 5030B, 5035/5035A and 3585 for preparation). In purge and trap, the analytes are stripped from the sample using helium and trapped on an adsorbent tube. The tube is heated while being backflushed with helium to carry the analytes to the GC/MS system. The analytes are separated in the gas chromatograph by a combination of the temperature program and the capillary column. The analytes are then detected by the mass spectrometer. Analytes are identified by comparing the mass spectra of known standards with the mass spectra of the sample. Analytes are quantitated relative to known standards using the internal standard method.

6. Definitions

6.1 Laboratory Quality System SOP QS08 **"**Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" provides information on the commonly used definitions.

7. Interferences

7.1 Section 3.0 of SW-846 Method 8260B details interferences and potential problems which may be encountered when dealing with volatile analyses.

8. Safety

8.1 Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed labwide.

9. Equipment & Supplies

9.1 GC : HP 5890 or 6890, temperature programmable, suitable for split or splitless injection.

9.2 Column: HP-VOC, 30 meter x 0.2 mm I.D. 1.12 µm film thickness silicon coated fused silica capillary column or equivalent.

9.3 M.S.: HP 5971, 5972 or 5973 capable of scanning 35 to 500 amu every one second or less, using 70 volts electron energy in electron impact ionization mode. The MS is capable of producing a mass spectrum for p-Bromofluorobenzene, BFB, which meets all tuning criteria for EPA methods [when 1 µL (50 ng) of the GC/MS tuning standard is introduced to the GC.]

9.4 Purge and Trap Unit

9.4.1 Concentrators: Tekmar/Dohrmann 3000/3100 Sample Concentrator equipped with Supelco trap number 2-4920-U VOCARB 3000, or equivalent, providing good delivery for all target compounds.

9.1.1 Autosamplers: Varian Archon 51 position programmable autosampler with 5ml to 25ml water and heated soil capability.

9.5 Acquisition Software: HP Chemstation system interfaced to the GC/MS. The system acquires and stores data throughout the chromatographic programs.

9.6 Data Processing Software: HP Chemstation data system. The system accepts and stores acquired data. It plots by extracted ion current profile (EICP). The system is also capable of integrating the abundances of any EICP between specified time or scan-number limits. NIST98.L mass spectral library is installed.

9.7 Microsyringes – 1.0, 5.0,10, 25, 50, 100, 250, 500 and 1000 µL.

9.8 Syringes – 5, 25 and 50 mL, gas-tight with Luer end.

9.9 Balance - analytical, 0.0001 g; top-loading, 0.01 g.

9.10 Disposable pasteur pipets.

9.11 Volumetric flasks, Class A - 2 mL, 5 mL, 10 mL, 50 mL, 100 mL and 250 mL with ground-glass stoppers.

9.12 Wooden tongue depressors

9.13 Glass scintillation vials - 20mL with screw caps.

9.14 Latex or Nitrile Gloves

9.15 pH paper (measures pH from 0-14).

10. Reagents and Standards

10.1 The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory. The following information relates to the specific reagents and standards used for the performance of the method:

10.2 Organic-free reagent water - obtained from the charcoal filter system in the VOA laboratory.

10.3 Methanol - Purge and trap grade (EM-Omnisolv EM-0482-6 or equivalent)

10.4 Methanol - suitable for use in gas chromatography (B&J Omnisolv MX0484-1, or equivalent)

10.5 Sodium bisulfate, $NaHSO_4$ – ACS reagent grade, or equivalent. Available from Aldrich (Part No. 30,782-3).

10.6 Stock standards are purchased in mixtures from reputable vendors. The date they are received is noted on the label. The date they are opened is noted on the label and recorded in the LIMS system along with their lot number and vendor and given a sequential number. Each standard label is completed with the standard number, name, preparation date, expiration date, solvent and analyst initials. Stock standards, when opened, have an expiration date of 6 months, **except for gas standards for South Carolina samples which have a one week expiration date**. All stocks and standards are stored in the freezer at a temperature of -15°C $\pm$ 5°C or less from the date they are received/prepared. The freezer temperature is monitored daily with a calibrated thermometer (annual calibration for liquid in glass and quarterly calibration for digital) and recorded with calibration correction in the VOA refrigerator/freezer logbook. Minimum and maximum temperatures are recorded after weekends/holidays. Makeup of common standards is detailed below. See standard information in LIMS system for makeup of other standards.

10.6.1 The Bromofluorobenzene (BFB) tuning standard is prepared as follows: Using a 50µL syringe, 25µL of standard (BFB @ 10000ng/µL) is injected into a 5mL volumetric flask containing approximately 4.0mL P&T methanol (Vendor,Lot) and diluted to volume with same making a 50ng/µL standard. After capping and inverting 3 times, the solution is transferred to a labeled teflon-lined, screw-capped vial and stored in the freezer at -15°C $\pm$ 5°C or less for up to a year **(1 week for South Carolina samples)**. A direct injection of 1µL (or equivalent purge) is used to tune the instrument.

10.6.2 The internal and surrogate standards are prepared as follows: Using the indicated syringe, the indicated amount of standard is injected into a 50 mL volumetric flask containing P&T methanol (Vendor,Lot) and diluted to volume with same making a 150ng/µL standard. After capping and inverting 3 times, the solution is transferred to the Archon standard vial and stored under helium for 1 month or less. Each 8260/624 sample is automatically injected with 1µL of this standard. (The internal standard/surrogate solution may be replaced if the –50%-200% criteria exceeds in the CCV when calculated against the midpoint of the ICAL or previous CCV.)

Standard	Conc. (ng/µL)	Syringe (µL)	Amount (µL)
8260 ISTD Mix	2500	1000	3000
Surr. Mix	2500	1000	3000

10.6.3 Calibration standards are prepared from the vendor stock standards at appropriate concentrations as follows. Occasionally unusual compounds are added to the mix so it is best to check the LIMS for exact standard makeup. Note: for laboratory blank spikes (BS), alternate sources or lot numbers from the main calibration standard are used to make the BS standard.

10.6.3.1 Primary Standard: Using the indicated syringe, the indicated amount of standard is injected into a 2mL volumetric flask containing approximately 1.0mL P&T methanol (Vendor,Lot) and diluted to volume with same to make a 100-500ng/µL standard. After capping and inverting 3 times, the solution is transferred into 2ml amber vial w/mini-inert valve and stored in the freezer at -15°C ± 5°C for 1 week. A 100µg/L (5mL purge) standard is made using 50µL of this standard to 50mLof reagent water.

Stock Standard(CCV)	Conc (ng/µL)	Syringe(µL)	Amount(µL)	Final Conc (ng/µL)
Custom 2 Mix	2000-40000	250	200	200-4000
Ketones Mix	5000	250	160	400
Liquid mix	2000	250	200	200
Custom mix	2000-10000	250	200	200-1000
Gases **(cat#30042)**	2000	250	200	200
Oxygenates **(CC2098.10)**	2000-10000	250	200	200-1000

Additional compounds may be added such as Appendix IX. Refer to standard ID in LIMS system.

10.6.4 ICV/BS/Matrix Spike Mix: A second source standard is used to check the validity of the gas and primary calibration standards used in analyzing the calibration curve. Using the indicated syringe, the indicated amount of standard is injected into a 2mL volumetric flask containing approximately 1.0mL P&T methanol (Vendor,Lot) and diluted to volume with same to make a 100-500ng/µL standard. After capping and inverting 3 times, the solution is transferred into 2ml amber vial w/mini-inert valve and stored in the freezer at -15°C ± 5°C for 1 week. A 50µg/L ICV/BS/Matrix Spike is made using 25µL of this standard to 50mL of reagent water/Sample Matrix.

Stock Standard(ICV/BS)	Conc (ng/µL)	Syringe(µL)	Amount(µL)	Final Conc (ng/µL)
Custom 2 mix	2000-40000	100	100	100-2000
Oxygenates	2000-10000	100	100	100-500
Ketones	5000	100	80	200
Liquid mix	2000	100	100	100
Custom Mix	2000-10000	100	100	100-500
Gases	2000	100	100	100

11. Sample Collection, Preservation, Shipment, and Storage

13.1 Quality Systems SOP QS10 related to Sample Receipt, Handling, & Processing provides details for collection, preservation, shipment, and storage.

13.2 All water samples are stored in the "True" refrigerator in the VOA lab at a temperature of 4°C. All unpreserved soil samples in TerraCore or encores are stored in the freezer in the VOA lab. All soil samples in bulk jars or chemically preserved TerraCore are stored in the soil walk-in refrigerator at a temperature of 4°C. Non-preserved water volatile samples have a holding time of 7 days from date of sampling. Preserved water samples and soil volatile samples have a holding time of 14 days from date of sampling (unless otherwise specified for the project). The temperature is monitored daily with a calibrated thermometer (annual calibration for liquid in glass and quarterly calibration for digital) and recorded with calibration correction in the VOA refrigerator/freezer logbook. The weekend temperature is monitored with a Min/Max thermometer and recorded upon arrival next business day.

12. Quality Control

12.1 Quality Systems SOP QS08 "Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" outlines details related to laboratory wide protocols on quality control.

12.1 Internal Standards - All samples and QC are spiked with internals. See **Table 2** for acceptance criteria and corrective action.

12.2 Surrogates - All samples and QC are spiked with surrogates. See **Table 2** of this SOP for acceptance criteria and corrective action.

12.3 BS Sample - A BS is analyzed every 12 hour tune. To prepare the BS, a blank is spiked with standards prepared from an alternate vendor or lot number from the calibration standards. Note: the concentration of the BS will be 20 µg/L when analyzing 624 samples (QC Check Sample). See **Table 2** of this SOP for acceptance criteria and corrective action. **When analyzing samples for South Carolina the limits are 70-130% except for poor purgers which are 60-140%.**

12.4 Method Blanks - A method blank is analyzed every 12 hour tune. See **Table 2** of this SOP for acceptance criteria and corrective action..

12.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample - 1 in 20 samples are spiked for an MS/MSD with the BS standard. See **Table 2** of this SOP for acceptance criteria and corrective action. MS data evaluation must include the consideration of the following factors.

12.5.1 Sample matrix - If the sample is a soil, grab sample or sequentially collected water sample it may affect the %R and RPD of the MS/MSD. A water sample which was taken from the same VOA vial for the original sample and the MS/MSD should have very good RPDs unless there has been a method problem. Corrective action must be taken in the form of reanalysis if a method problem is indicated.

12.5.2 Original sample concentration - If a spiked compound has a problem and the concentration of that compound in the original sample was four or more times

the concentration of the spike, no further corrective action may be necessary other than the generation of a corrective action report to document the problem.

12.5.3 MS vs. MSD - If a spiked compound has a problem in both the MS and MSD, review the BS and if acceptable no further action may be necessary since it is attributable to matrix effect.

12.5.4 Non-target Interference - The presence of significant non-target interference should be brought to the immediate attention of your supervisor who should discuss the problem with the client/project manager to determine the action to be taken.

13. Calibration and Standardization

13.1 Quality Systems **SOP QS08 "**Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.

13.2 Chromatographic conditions – Refer to corresponding instrument maintenance log for current gas chromatograph, mass spectrometer, and concentrator conditions.

13.3 System Bakeout - Prior to analysis an instrument blank is analyzed.

NOTE: Further cleaning may be accomplished by backflushing the lines with methanol and then analyzing blanks overnight.

13.4 Tuning - Prior to any calibration or analysis, BFB tuning criteria must be met for a 1.0µL injection of the tuning standard. See **Table 5** of this SOP for acceptance criteria. Tune must be met every 12 hours sample analysis is to be performed **(every 24 hours for *Federal Register* Method 624 except for South Carolina which only allows 12 hours).** The mass spectrum of BFB is acquired as follows: by using the BFB method in Target (which uses three scans with backround subtraction) to process the BFB data file. If the BFB tune does not pass criteria corrective action should be taken

13.5 **Calibration:** Calibration standards are made up in water using the appropriate amount of the methanol standard. See the LIMS for preparation of standards. **Calibration for soils for South Carolina requires that 5mL of sodium bisulfate solution is added to each calibration standard made if the samples will be preserved with sodium bisulfate.** All manual calibration integrations must be approved by the section manager or designated peer reviewer.

13.5.1 Initial Calibration - An initial calibration curve at no less than five (six if using a quadratic curve fit) concentration levels for analytes and surrogates must be analyzed and shown to meet the initial calibration criteria before any sample analysis may be performed. See **Table 2** of this SOP for acceptance criteria and corrective action. The lowest standard must be less than or equal to the reported quantitation limit and the highest standard must not exceed the linear range of the detector. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**)

initialed, dated, and reason with the quantitation report and chromatograms. All manual calibration integrations must be approved by the section manager or designated peer reviewer Any response factors less than 0.050 must be supported by the mass spectrum of the lowest standard. **No quadratic curves for South Carolina.**

CCCs:	1,1-Dichloroethene	Toluene
	Chloroform	Ethylbenzene
	1,2-Dichloropropane	Vinyl chloride

SPCCs:	Chloromethane	0.10
	1,1-Dichloroethane	0.10
	Bromoform	0.10
	Chlorobenzene	0.30
	1,1,2,2-Tetrachloroethane	0.30

13.5.2 Initial Calibration Verification (ICV) - A second source standard is prepared at or near the CCV concentration and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analysis may be performed. See **Table 2** of this SOP for acceptance criteria and corrective action. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, dated, and reason with the quantitation report and chromatograms. All manual ICV integrations must be approved by the section manager or designated peer reviewer.

13.5.3 Continuing Calibration Verification (CCV) - A CCV is analyzed every 12 hour tune and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analysis may be performed. See **Table 2** of this SOP for acceptance criteria and corrective action. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, dated, and reason with the quantitation report and chromatograms. All manual CCV integrations must be approved by the section manager or designated peer reviewer.

NOTE: Acceptance criteria for method 624 consists of meeting recovery limits found in table 5 of the method for a QC check sample. This QC check sample is made from a separate source or lot number than the calibration standard at a concentration of 20 µg/L.

14. **Procedure**

14.1 BS - A BS is analyzed every 12 hour tune.Using standards prepared from an alternate vendor or lot number, blank water is spiked at the 50 µg/L (5mL/soil) or 10 µg/L (25mL) level. See **Table 2** of this SOP for acceptance criteria and corrective action. **Note: the concentration of the BS will be 20 µg/L when analyzing 624 samples (QC Check Sample).**

14.2 Method Blank - Prior to sample analysis, the system must be shown to be free of contamination through analysis of a method blank. See **Table 2** of this SOP for acceptance criteria and corrective action.

14.3 Sample Analysis - Prior to analysis, the samples are prepared for chromatography using the appropriate sample preparation method (5mL water, 25mL water, low soil, high soil, etc.) See SOP 225 for preparation of a 5035 soil sample. For a 5mL/25mL water sample, use the following procedure:

14.3.1 Load the vial into the Archon autosampler in the expected position.

14.3.2 Program the Archon for the loaded vial range and necessary dilutions, making sure the programmed method is set for the same volume as the purge vessel on the front of the LSC 2000 or 3000/3100 and that the Chemstation sequence matches the Archon sequence. Note: TCLP samples are analyzed at a 10x dilution. One TCLP sample is spiked per batch at receipt of leachates.

14.3.3 After analysis of the sample has been completed, check the pH of the sample using pH paper and verify it to be less than a pH of 2 (recorded on the sequence log). If it is not, record the pH on the sequence log and generate a non-conformance report. The sample report will have to be qualified for preservation if the analysis is being performed more than 7 days after sampling. [Note: TCLP samples do not require a pH check.]

14.4 **Instrument sequence**

An example of a typical instrument sequence log follows:

1-BFB Tune (12:00 am)
2-CCV
3-BS
4-RL standard
5-Method Blank
6-Sample
7-Sample
8-Sample
9-Sample
10-Sample
11-Sample
12-Sample
13-Sample
14-Sample
15-Sample
16-Sample
17-Sample
18-Sample MS
19-Sample MSD
20-BFB (12:00pm - 12 hours since last BFB/CCV)
21-CCV
22-BS
23-Method Blank
24-Sample
25-Sample

14.5 Data Reduction/Evaluation - Each sample analysis sequence is documented using the computer run log generated on the chemstation. This run log is signed, dated and paginated then placed in a 3 ring binder for that instrument. After the sample has

been analyzed, the data is processed through the Chemstation data system. Quantitative measurements are performed using the calculations found in section 15.2 of this SOP. The following must be checked to determine if the sample will need any reanalysis or dilution. See **Table 2** of this SOP for acceptance criteria and corrective action. Formal data evaluation is detailed in SOP QS05. **See SOP QS07 for guidance on manual integrations.**

14.5.1 Internal Standards - Areas counts and retention times.

14.5.2 Surrogates – Recoveries and retention times.
***Federal Register* Method 624 contains no criteria for surrogate recovery.**

Surrogate	WATER	SOIL
Dibromofluoromethane	85-120	80-125
1,2-Dichloroethane-d4	85-135	75-140
Toluene-d8	85-115	80-120
Bromofluorobenzene	80-120	80-125

14.5.3 Analyte concentration.

14.5.4 Qualitative identification based on spectrum and retention time.

15. Data Analysis and Calculations

15.1 Quality Systems SOP QS09 "General and Commonly used Laboratory Calculations" provides details on general calculations used throughout the laboratory.

15.2 Calculations:

13.1.1 The RF is calculated as follows:

$$RF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

where:
A_s = Peak area (or height) of the analyte or surrogate.
A_{is} = Peak area (or height) of the internal standard.
C_s = Concentration of the analyte or surrogate.
C_{is} = Concentration of the internal standard.

15.2.2 Calibration verification involves the calculation of the percent drift (linear) or the percent difference (average) of the instrument response between the initial calibration and each subsequent analysis of the verification standard. Use the equations below to calculate % Drift or % Difference, depending on the calibration procedure used.

$$\% \text{ Drift} = \frac{(\text{Calculated concentration} - \text{Theoretical concentration}) * 100}{\text{Theoretical Concentration}}$$

where the calculated concentration is determined from the initial calibration and the theoretical concentration is the concentration at which the standard was prepared.

$$\% \text{ Difference} = \frac{(\text{CCV RF} - \text{Average RF}) * 100}{\text{Average RF}}$$

where CCV RF is the response factor from the analysis of the verification standard and Average RF is the average response factor from the initial calibration. The % difference or % drift calculated for the calibration verification standard must be within ±20% for each CCC analyte, or for all target analytes if the CCCs are not target analytes, before any sample analyses may take place.

15.2.3 Concentration in water samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to ug/L.]

$$\text{Concentration } (\mu g/L) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(V_s)(1000)}$$

where:

A_s = Area (or height) of the peak for the analyte in the sample.

A_{is} = Area (or height) of the peak for the internal standard.

C_{is} = Concentration of the internal standard in the volume purged in ug/L.

D = Dilution factor, if the sample was diluted prior to analysis. If no dilution was made, D = 1. The dilution factor is always dimensionless.

V_i = For purge-and-trap analysis, V_i is not applicable and is set at 1.

$\overline{RF}$ = Mean response factor from the initial calibration.

V_s = Volume of the aqueous sample purged (mL). If units of liters are used for this term, multiply the results by 1000.

15.2.4 Concentration in non-aqueous samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to ug/kg.]

$$\text{Concentration } (\mu g/kg) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(W_s)(1000)}$$

where: A_s, A_{is}, C_{is}, D, and $\overline{RF}$ are the same as for aqueous samples.

W_s = Weight of sample extracted (g). Either a dry weight or wet weight may be used, depending upon the specific application of the data. If units of kilograms are used for this term, multiply the results by 1000.

16. **Method Performance**

16.1 Demonstration of Capability (DOC): Each analyst must perform a DOC prior to reporting data. The analyst must prepare (for prep technicians) and analyze (analysts reviewing and reporting data) 4-BS samples. The data is calculated for accuracy and precision requirements. The DOC form is completed by each analyst and then provided to the supervisor for further processing and approval. See **Table 2** for acceptance criteria.

17. **Pollution Prevention**

17.1 Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18. **Data Assessment and Acceptance Criteria for Quality Control Measures**

18.1 Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures. **Table 2** of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19. **Contingencies for Handling out-of-control or unacceptable data**

19.1 Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on handling out of control data. Table 2 within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

20. **Waste Management.**

20.1 Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

21. **References**

21.1 40 CFR, Part 136; Appendix A
21.2 Test Methods for Evaluating Solid Waste, SW-846, Third Edition and updates
21.3 National Environmental Laboratory Accreditation Conference; CH. 5, 2001
21.4 USACE, EM 200-1-3; Appendix 1; Shell, 2/2001
21.5 DOD Quality Systems Manual for Environmental Laboratories version 3, 3/2005
21.6 DOD Quality Systems Manual for Environmental Laboratories version 4.1, 4/2009
21.7 DOD Quality Systems Manual for Environmental Laboratories version 4.2, 10/2010

22. Tables, Diagrams, Flowcharts and Validation Data

22.1 Table 1, all parameters with DL(MDL)/LOD/LOQ(MRL).
22.2 Table 2, QA/QC summary table
22.3 Table 3, Technical Completeness / Accuracy Checklist
22.4 Table 4, Data Reviewers Checklist(s)
22.5 Table 5, BFB Tuning Criteria
22.6 Table 6, Analyst Checklist
22.7 Table 7, INTERNAL STANDARD ASSOCIATION

Table 1 – DL/LOD/LOQ

Analyte	MDL/DL	LOD	MRL/LOQ	Units
1,1,1,2-Tetrachloroethane	1.25	2.50	5.00	ug/Kg
1,1,1-Trichloroethane (1,1,1-TCA)	1.25	2.50	5.00	ug/Kg
1,1,2,2-Tetrachloroethane	1.25	2.50	5.00	ug/Kg
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)	2.50	5.00	10.0	ug/Kg
1,1,2-Trichloroethane	1.25	2.50	5.00	ug/Kg
1,1-Dichloroethane (1,1-DCA)	1.25	2.50	5.00	ug/Kg
1,1-Dichloroethene (1,1-DCE)	1.25	2.50	5.00	ug/Kg
1,1-Dichloropropene	1.25	2.50	5.00	ug/Kg
1,2,3-Trichlorobenzene	1.25	2.50	5.00	ug/Kg
1,2,3-Trichloropropane	1.25	2.50	5.00	ug/Kg
1,2,4-Trichlorobenzene	1.25	2.50	5.00	ug/Kg
1,2,4-Trimethylbenzene	1.25	2.50	5.00	ug/Kg
1,2-Dibromo-3-chloropropane (DBCP)	2.50	5.00	10.0	ug/Kg
1,2-Dibromoethane (EDB)	1.25	2.50	5.00	ug/Kg
1,2-Dichlorobenzene	1.25	2.50	5.00	ug/Kg
1,2-Dichloroethane (EDC)	1.25	2.50	5.00	ug/Kg
1,2-Dichloropropane	1.25	2.50	5.00	ug/Kg
1,3,5-Trimethylbenzene	1.25	2.50	5.00	ug/Kg
1,3-Dichlorobenzene	1.25	2.50	5.00	ug/Kg
1,3-Dichloropropane	1.25	2.50	5.00	ug/Kg
1,4-Dichlorobenzene	1.25	2.50	5.00	ug/Kg
2,2-Dichloropropane	1.25	2.50	5.00	ug/Kg
2-Butanone (Methyl ethyl ketone; MEK)	2.50	5.00	10.0	ug/Kg
2-Chlorotoluene	1.25	2.50	5.00	ug/Kg
2-Hexanone (Methyl butyl ketone; MBK)	1.25	2.50	5.00	ug/Kg
4-Chlorotoluene	1.25	2.50	5.00	ug/Kg
4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)	1.25	2.50	5.00	ug/Kg
Acetone	5.00	10.0	20.0	ug/Kg
Acrolein	5.00	10.0	20.0	ug/Kg
Acrylonitrile	5.00	10.0	20.0	ug/Kg
Benzene	1.25	2.50	5.00	ug/Kg
Bromobenzene	1.25	2.50	5.00	ug/Kg
Bromochloromethane	1.25	2.50	5.00	ug/Kg
Bromodichloromethane	1.25	2.50	5.00	ug/Kg
Bromoform	1.25	2.50	5.00	ug/Kg
Bromomethane	2.50	5.00	10.0	ug/Kg
Carbon Disulfide	1.25	2.50	5.00	ug/Kg
Carbon Tetrachloride	1.25	2.50	5.00	ug/Kg
Chlorobenzene	1.25	2.50	5.00	ug/Kg
Chloroethane	2.50	5.00	10.0	ug/Kg
Chloroform	1.25	2.50	5.00	ug/Kg
Chloromethane	2.50	5.00	10.0	ug/Kg
cis-1,2-Dichloroethene (cis-1,2-DCE)	1.25	2.50	5.00	ug/Kg
cis-1,3-Dichloropropene	1.25	2.50	5.00	ug/Kg
Cyclohexane	1.25	2.50	5.00	ug/Kg
Dibromochloromethane	1.25	2.50	5.00	ug/Kg
Dibromomethane	1.25	2.50	5.00	ug/Kg
Dichlorodifluoromethane (CFC-12)	2.50	5.00	10.0	ug/Kg
Ethyl methacrylate	1.25	2.50	5.00	ug/Kg
Ethylbenzene	1.25	2.50	5.00	ug/Kg
Hexachlorobutadiene	1.25	2.50	5.00	ug/Kg
Iodomethane	5.00	10.0	20.0	ug/Kg
Isopropylbenzene (Cumene)	1.25	2.50	5.00	ug/Kg
Methyl Acetate	2.50	5.00	10.0	ug/Kg
Methyl methacrylate	1.25	2.50	5.00	ug/Kg
Methyl Tertiary Butyl Ether (MTBE)	1.25	2.50	5.00	ug/Kg
Methylcyclohexane	1.25	2.50	5.00	ug/Kg
Methylene Chloride, or Dichloromethane	2.50	5.00	10.0	ug/Kg

Analyte	MDL/DL	LOD	MRL/LOQ	Units
Naphthalene	1.25	2.50	5.00	ug/Kg
n-Butylbenzene	1.25	2.50	5.00	ug/Kg
n-Propylbenzene	1.25	2.50	5.00	ug/Kg
p-Isopropyltoluene	1.25	2.50	5.00	ug/Kg
sec-Butylbenzene	1.25	2.50	5.00	ug/Kg
Styrene	1.25	2.50	5.00	ug/Kg
tert-Butylbenzene	1.25	2.50	5.00	ug/Kg
Tetrachloroethene (PCE; PERC)	1.25	2.50	5.00	ug/Kg
Toluene	1.25	2.50	5.00	ug/Kg
trans-1,2-Dichloroethene (trans-1,2-DCE)	1.25	2.50	5.00	ug/Kg
trans-1,3-Dichloropropene	1.25	2.50	5.00	ug/Kg
Trichloroethene (TCE)	1.25	2.50	5.00	ug/Kg
Trichlorofluoromethane (CFC-11)	2.50	5.00	10.0	ug/Kg
Vinyl acetate	2.50	5.00	10.0	ug/Kg
Vinyl Chloride (VC)	2.50	5.00	10.0	ug/Kg
m,p-Xylene	2.50	5.00	10.0	ug/Kg
o-Xylene	1.25	2.50	5.00	ug/Kg
1,1,1,2-Tetrachloroethane	0.25	0.50	1.00	ug/L
1,1,1-Trichloroethane (1,1,1-TCA)	0.25	0.50	1.00	ug/L
1,1,2,2-Tetrachloroethane	0.25	0.50	1.00	ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)	0.50	1.00	2.00	ug/L
1,1,2-Trichloroethane	0.25	0.50	1.00	ug/L
1,1-Dichloroethane (1,1-DCA)	0.25	0.50	1.00	ug/L
1,1-Dichloroethene (1,1-DCE)	0.25	0.50	1.00	ug/L
1,1-Dichloropropene	0.25	0.50	1.00	ug/L
1,2,3-Trichlorobenzene	0.25	0.50	1.00	ug/L
1,2,3-Trichloropropane	0.50	1.00	2.00	ug/L
1,2,4-Trichlorobenzene	0.25	0.50	1.00	ug/L
1,2,4-Trimethylbenzene	0.25	0.50	1.00	ug/L
1,2-Dibromo-3-chloropropane (DBCP)	0.50	1.00	2.00	ug/L
1,2-Dibromoethane (EDB)	0.25	0.50	1.00	ug/L
1,2-Dichlorobenzene	0.25	0.50	1.00	ug/L
1,2-Dichloroethane (EDC)	0.25	0.50	1.00	ug/L
1,2-Dichloropropane	0.25	0.50	1.00	ug/L
1,3,5-Trimethylbenzene	0.25	0.50	1.00	ug/L
1,3-Dichlorobenzene	0.25	0.50	1.00	ug/L
1,3-Dichloropropane	0.25	0.50	1.00	ug/L
1,4-Dichlorobenzene	0.25	0.50	1.00	ug/L
1-Chlorohexane	0.50	1.00	2.00	ug/L
2,2-Dichloropropane	0.25	0.50	1.00	ug/L
2-Butanone (Methyl ethyl ketone; MEK)	2.50	5.00	10.0	ug/L
2-Chloroethyl vinyl ether	1.25	2.50	5.00	ug/L
2-Chlorotoluene	0.25	0.50	1.00	ug/L
2-Hexanone (Methyl butyl ketone; MBK)	1.25	2.50	5.00	ug/L
4-Chlorotoluene	0.25	0.50	1.00	ug/L
4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)	1.25	2.50	5.00	ug/L
Acetone	2.50	5.00	10.0	ug/L
Acrolein	1.25	2.50	5.00	ug/L
Acrylonitrile	2.50	5.00	10.0	ug/L
Benzene	0.25	0.50	1.00	ug/L
Bromobenzene	0.25	0.50	1.00	ug/L
Bromochloromethane	0.25	0.50	1.00	ug/L
Bromodichloromethane	0.25	0.50	1.00	ug/L
Bromoform	0.25	0.50	1.00	ug/L
Bromomethane	0.50	1.00	2.00	ug/L
Carbon Disulfide	0.25	0.50	1.00	ug/L
Carbon Tetrachloride	0.25	0.50	1.00	ug/L
Chlorobenzene	0.25	0.50	1.00	ug/L
Chloroethane	0.50	1.00	2.00	ug/L
Chloroform	0.25	0.50	1.00	ug/L
Chloromethane	0.25	0.50	1.00	ug/L
cis-1,2-Dichloroethene (cis-1,2-DCE)	0.25	0.50	1.00	ug/L

Analyte	MDL/DL	LOD	MRL/LOQ	Units
cis-1,3-Dichloropropene	0.25	0.50	1.00	ug/L
Cyclohexane	0.25	0.50	1.00	ug/L
Dibromochloromethane	0.25	0.50	1.00	ug/L
Dibromomethane	0.25	0.50	1.00	ug/L
Dichlorodifluoromethane (CFC-12)	0.50	1.00	2.00	ug/L
Di-isopropyl ether	0.25	0.50	1.00	ug/L
ETBE	0.25	0.50	1.00	ug/L
Ethyl methacrylate	0.25	0.50	1.00	ug/L
Ethylbenzene	0.25	0.50	1.00	ug/L
Hexachlorobutadiene	0.25	0.50	1.00	ug/L
Iodomethane	0.25	0.50	1.00	ug/L
Isopropylbenzene (Cumene)	0.25	0.50	1.00	ug/L
Methyl Acetate	0.50	1.00	2.00	ug/L
Methyl methacrylate	0.25	0.50	1.00	ug/L
Methyl Tertiary Butyl Ether (MTBE)	0.25	0.50	1.00	ug/L
Methylcyclohexane	0.25	0.50	1.00	ug/L
Methylene Chloride, or Dichloromethane	0.50	1.00	2.00	ug/L
Naphthalene	0.25	0.50	1.00	ug/L
n-Butylbenzene	0.25	0.50	1.00	ug/L
n-Propylbenzene	0.25	0.50	1.00	ug/L
p-Isopropyltoluene	0.25	0.50	1.00	ug/L
sec-Butylbenzene	0.25	0.50	1.00	ug/L
Styrene	0.25	0.50	1.00	ug/L
t-Butyl alcohol	1.25	2.50	5.00	ug/L
tert-Amyl methyl ether	2.50	5.00	10.0	ug/L
tert-Butylbenzene	0.25	0.50	1.00	ug/L
Tetrachloroethene (PCE; PERC)	0.25	0.50	1.00	ug/L
Tetrahydrofuran	1.25	2.50	5.00	ug/L
Toluene	0.25	0.50	1.00	ug/L
trans-1,2-Dichloroethene (trans-1,2-DCE)	0.25	0.50	1.00	ug/L
trans-1,3-Dichloropropene	0.25	0.50	1.00	ug/L
Trichloroethene (TCE)	0.25	0.50	1.00	ug/L
Trichlorofluoromethane (CFC-11)	0.50	1.00	2.00	ug/L
Vinyl acetate	1.25	2.50	5.00	ug/L
Vinyl Chloride (VC)	0.50	1.00	2.00	ug/L
m,p-Xylene	0.50	1.00	2.00	ug/L
o-Xylene	0.25	0.50	1.00	ug/L

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Method 8260B)					
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Demonstrate acceptable analytical capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix.	QC acceptance criteria published by DoD, if available; otherwise, method-specific criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f of DoD QSM 4.2).	NA.	This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete.
MDL determination	Initial method demonstration required for some states – not required for DoD	Refer to SOP QS09.			
LOD determination and verification	Prior to initial analysis then quarterly verification.	See Box D-13 of DoD QSM 4.2			
LOQ establishment and verification	Prior to initial analysis then quarterly verification.	See Box D-14 of DoD QSM 4.2			
Tuning	Prior to ICAL and at the beginning of each 12-hour period.	Refer to table 5 of this SOP.	Retune instrument and verify. Rerun affected samples.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be accepted without a valid tune.
Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis.	1. Average response factor (RF) for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. 2. RSD for RFs for CCCs: VOCs ≤ 30% and one option below: **Option 1:** RSD for each analyte ≤ 15%; **Option 2:** linear least squares regression r ≥ 0.995; **Option 3**: non-linear regression–coefficient of determination (COD) r2 ≥ 0.99 (6 points shall be used for second order, 7 points shall be used for third order).	Correct problem then repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin for DoD projects.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260B) (continued)					
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Second source calibration verification (ICV)	Once after each ICAL.	All project analytes within ± 20% of true value. [± 25% for non-DoD 8260B;]	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until calibration has been verified.
Retention time window position establishment for each analyte and surrogate	Once per ICAL.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the sequence CCV is used.	NA.	NA.	
Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ± 0.06 RRT units. Note - retention times may be updated based on the CCV to account for minor performance fluctuations or after routine system maintenance (such as column clipping).	Correct problem, then rerun ICAL.	Flagging criteria are not appropriate.	With each sample, the RRT shall be compared with the most recently updated RRT. If the RRT has changed by more than ±0.06 RRT units since the last update, this indicates a significant change in system performance and the laboratory must take appropriate corrective actions as required by the method and rerun the ICAL to reestablish the retention times.
Continuing calibration verification (CCV)	Daily before sample analysis and every 12 hours of analysis time.	1. Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. 2. %Difference/Drift for all target compounds and surrogates: VOCs ≤ 20%D (Note: D = difference when using RFs or drift when using least squares regression or non-linear calibration). [± 20% for CCCs only non-DoD 8260B]	DoD project level approval must be obtained for each of the failed analytes or corrective action must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply qualifier to all results for the specific analyte(s) in all samples since last acceptable CCV. [For non-DoD 8260B, if CCCs exceed, evaluate all analytes for 20%D and qualify as above]	Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed, holding time has been exceeded or client has approved reporting.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260B) (continued)					
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL or daily CCV; EICP area within -50% to +100% of ICAL midpoint standard or daily CCV.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	If corrective action fails in field samples, apply qulaifier to analytes associated with the non-compliant IS. Flagging criteria are not appropriate for failed standards.	Sample results are not acceptable without a valid IS verification.
Method blank	One per preparatory batch.	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected >RL/LOQ	Correct problem. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
BS containing all analytes to be reported, including surrogates	One per preparatory batch.	QC acceptance criteria specified by client or DoD (appendix G), if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean BS recovery.	Correct problem, then reprep and reanalyze the BS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid BS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Matrix Spike (MS)	One per preparatory batch per matrix (see Box D-7).	Use BS criteria, above.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	For matrix evaluation only. If MS results are outside the BS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.
Matrix spike duplicate (MSD) or sample duplicate	One per preparatory batch per matrix (see Box D-7).	MSD: For matrix evaluation, use BS acceptance criteria above. MSD or sample duplicate: RPD ≤ 30% or client specified limit (between MS and MSD or sample and sample duplicate).	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	The data shall be evaluated to determine the source of difference.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260B) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Surrogate spike	All field and QC samples.	<u>**Surrogate**</u> / **WATER** / **SOIL** Dibromofluoromethane / 85-120 / 80-125 1,2-Dichloroethane-d4 / 85-135 / 75-140 Toluene-d8 / 85-115 / 80-120 Bromofluorobenzene / 80-120 / 80-125 QC acceptance criteria specified by DoD (above) or Client. Otherwise, in-house control limits may be used. No limits specified for Method 624.	For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Apply qualifier to all associated analytes if acceptance criteria are not met.	Alternative surrogates are recommended when there is obvious chromatographic interference.
Results reported between DL and LOQ	NA.	NA.	NA.	Apply J-flag to all results between DL and LOQ.	

Table 3, Technical Completeness / Accuracy Checklist

13. Were all the QC check elements analyzed – refer to Table 2 of the SOP
14. Were the QC criteria met
15. In cases of failures, was there an NCR written
16. Were all manual integrations signed
17. Were dilution factors applied correctly
18. Was there supervisory approval for manual integrations on standards and QC samples
19. Was the data uploaded into LIMS via direct upload – if yes, then was a cross check subset of the uploaded values performed
20. If the data was entered into LIMS manually, was a check of all entered values performed
21. Was the red marked data in LIMS checked for accuracy and the corresponding hard copy data documented appropriately
22. Were proper data qualifiers applied to the data in LIMS
23. Was the hard copy package checked for completeness to include all data for the sequence such that the data reviewer could reconstruct sample analyses and validate / approve the data

Table 4, Data Reviewers Checklist (Prior to approving data)

13. Does the hard copy raw data (or electronic raw data) package look complete and include all data points
14. Were QA objectives met and for failures were the appropriate actions taken
15. For direct uploads to LIMS, did a subset cross check match the raw data
16. Did all the manual entries into LIMS match the raw data
17. Were there appropriate signatures and documentation on the raw data
18. Were appropriate LIMS flags used
19. Were manual integrations signed
20. Were manual integrations for calibration and QC samples approved by supervisor
21. Were manual calculations verified

Table 5, Tuning Criteria

m/z	Required Intensity (relative abundance)
50	15 to 40% of m/z 95
75	30 to 60% of m/z 95
95	Base peak, 100% relative abundance
96	5 to 9% of m/z 95
173	Less than 2% of m/z 174
174	Greater than 50% of m/z 95
175	5 to 9% of m/z 174
176	Greater than 95% but less than 101% of m/z 174
177	5 to 9% of m/z 176

Table 6, ANALYST DATA REVIEW CHECKLIST

Sample Number(s):	
Batch Number(s)/Target ID:	
Sequence Number/Calibration Number:	
Method: 8260B/624, 8270C/8270D/625	**NCR#_____**

QA/QC Item	Yes	No	NA	2nd Check
13. Was the autosampler tray verified against the sequence file?				
2. Is the BFB/DFTPP tune performed every 12 hours and is the tuning criteria met? For 8270 regular (not low PAH), have tailing and breakdown criteria been met?				
3. Are the % RSDs within 20% or 0.995 linear corr or 0.990 quadratic COD for all analytes in the initial calibration? Are SPCC response factor criteria met? Is recalc. of low stds within 50%-150% (preferred). Retention times checked for compounds with the same spectra (ex. Dichlorobenzenes). Concentrations checked for compounds with different conc. (ex. m/p-xylene, ketones,etc.).				
4. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met (+/-20% DoD, +/-25% method)? Are SPCC response factor criteria met?				
5. Does the Continuing Calibration Standard (CCV) meet the ± 20% difference criteria and IS within 50%-200% of calibration curve midpoint?				
6. Is the Method Blank run at the desired frequency and is its concentration for target analytes less than the RL (LOD for DoD except phthalates)?				
13. Are the BS, BSD, MS, MSD within control limits and run at the desired frequency?				
8. Are all sample holding times met, analytes within calibration range, IS areas within 50%-200% of CCV response and surrogate recoveries within limits?				
9. Sample_____shows calculation verified from raw areas to final LIMS concentration.				
22. Data uploaded to Element with correct analysts reflected?				

Comments on any "No" response:

_____

_____

_____

_____

Data uploaded?

Data Qualified?

Primary-Level Review: _____ Date: _____

Second-Level Review: _____ Date: _____

Table 7, Internal Standard Association

Analyte	Internal Standard	Analyte	Internal Standard
1,1,1-Trichloroethane	Fluorobenzene	1,1,1,2-Tetrachloroethane	d5-Chlorobenzene
1,1,2-Trichloro-1,2,2-trifluoroethane	Fluorobenzene	1,1,2-Trichloroethane	d5-Chlorobenzene
1,1-Dichloroethane	Fluorobenzene	1,2,3-Trichloropropane	d5-Chlorobenzene
1,1-Dichloroethene	Fluorobenzene	1,2-Dibromoethane (EDB)	d5-Chlorobenzene
1,1-Dichloropropene	Fluorobenzene	1,3-Dichloropropane	d5-Chlorobenzene
1,2-Dichloroethane	Fluorobenzene	1-Chlorohexane	d5-Chlorobenzene
1,2-Dichloroethane-d4	Fluorobenzene	2-Hexanone	d5-Chlorobenzene
1,2-Dichloroethene (total)	Fluorobenzene	Bromofluorobenzene	d5-Chlorobenzene
1,2-Dichloropropane	Fluorobenzene	Bromoform	d5-Chlorobenzene
1,4-Dioxane	Fluorobenzene	Chlorobenzene	d5-Chlorobenzene
2,2-Dichloropropane	Fluorobenzene	Chlorobenzene-d5	d5-Chlorobenzene
2-Butanone	Fluorobenzene	Dibromochloromethane	d5-Chlorobenzene
2-Chloroethyl vinyl ether	Fluorobenzene	Ethyl Methacrylate	d5-Chlorobenzene
4-Methyl-2-pentanone	Fluorobenzene	Ethylbenzene	d5-Chlorobenzene
Acetaldehyde	Fluorobenzene	m,p-Xylene	d5-Chlorobenzene
Acetone	Fluorobenzene	Methacrylonitrile	d5-Chlorobenzene
Acetonitrile	Fluorobenzene	o-Xylene	d5-Chlorobenzene
Acrolein	Fluorobenzene	Styrene	d5-Chlorobenzene
Acrylonitrile	Fluorobenzene	Tetrachloroethene	d5-Chlorobenzene
Allyl chloride	Fluorobenzene	Toluene	d5-Chlorobenzene
Benzene	Fluorobenzene	Toluene-d8	d5-Chlorobenzene
Bromochloromethane	Fluorobenzene	trans-1,3-Dichloropropene	d5-Chlorobenzene
Bromodichloromethane	Fluorobenzene	Xylenes (total)	d5-Chlorobenzene
Bromomethane	Fluorobenzene	1,1,2,2-Tetrachloroethane	1,4-dichlorobenzene-d4
Carbon disulfide	Fluorobenzene	1,2,3-Trichlorobenzene	1,4-dichlorobenzene-d4
Carbon tetrachloride	Fluorobenzene	1,2,4-Trichlorobenzene	1,4-dichlorobenzene-d4
Chloroethane	Fluorobenzene	1,2,4-Trimethylbenzene	1,4-dichlorobenzene-d4
Chloroform	Fluorobenzene	1,2-Dibromo-3-chloropropane	1,4-dichlorobenzene-d4
Chloromethane	Fluorobenzene	1,2-Dichlorobenzene	1,4-dichlorobenzene-d4
Chloroprene	Fluorobenzene	1,3,5-Trimethylbenzene	1,4-dichlorobenzene-d4
cis-1,2-Dichloroethene	Fluorobenzene	1,3-Dichlorobenzene	1,4-dichlorobenzene-d4
cis-1,3-Dichloropropene	Fluorobenzene	1,4-Dichlorobenzene	1,4-dichlorobenzene-d4
Cyclohexane	Fluorobenzene	1,4-Dichlorobenzene-d4	1,4-dichlorobenzene-d4
Dibromofluoromethane	Fluorobenzene	2-Chlorotoluene	1,4-dichlorobenzene-d4
Dibromomethane	Fluorobenzene	4-Chlorotoluene	1,4-dichlorobenzene-d4
Dichlorodifluoromethane	Fluorobenzene	Bromobenzene	1,4-dichlorobenzene-d4
Diisopropyl Ether	Fluorobenzene	cis-1,4-Dichloro-2-butene	1,4-dichlorobenzene-d4
Ethyl tert-Butyl Ether	Fluorobenzene	Hexachlorobutadiene	1,4-dichlorobenzene-d4
Fluorobenzene	Fluorobenzene	Naphthalene	1,4-dichlorobenzene-d4
Hexane	Fluorobenzene	n-Butylbenzene	1,4-dichlorobenzene-d4
Iodomethane	Fluorobenzene	n-Propylbenzene	1,4-dichlorobenzene-d4
Isobutyl alcohol	Fluorobenzene	p-Isopropyltoluene	1,4-dichlorobenzene-d4
Isopropylbenzene	Fluorobenzene	sec-Butylbenzene	1,4-dichlorobenzene-d4
Methyl Acetate	Fluorobenzene	tert-Butylbenzene	1,4-dichlorobenzene-d4
Methyl Methacrylate	Fluorobenzene	trans-1,4-Dichloro-2-butene	1,4-dichlorobenzene-d4
Methyl t-Butyl Ether	Fluorobenzene		
Methylcyclohexane	Fluorobenzene		
Methylene chloride	Fluorobenzene		
Propionitrile	Fluorobenzene		
t-Butyl alcohol	Fluorobenzene		
Tert-Amyl Methyl Ether	Fluorobenzene		
Tetrahydrofuran	Fluorobenzene		
trans-1,2-Dichloroethene	Fluorobenzene		
Trichloroethene	Fluorobenzene		
Trichlorofluoromethane	Fluorobenzene		
Vinyl acetate	Fluorobenzene		
Vinyl chloride	Fluorobenzene		

Corvallis ASL Standard Operating Procedure

ANALYTICAL METHOD FOR THE DETERMINATION OF VOLATILE ORGANICS IN AIR BY METHOD TO-14A / TO-15 USING CANISTERS AND GC/MS IN SCAN OR SIM MODE

METHOD BASED ON THE FOLLOWING SOURCE METHODS:

Preparatory Methods	**Analytical Methods**
N/A	EPA TO-14A and TO-15

APPROVED:

Mike Schaadt 01/18/12

Section Leader Date

CH2MHILL
Applied Sciences Laboratory (ASL)

SOP Change Form

☐	Temporary Change	**Analytical Batch/SDG:**		**Date:**	**03/19/12**
☒	Permanent Change	**Effective Date:**	**03/19/12**	**SOP No.:**	**AIR12**
				SOP Current Rev.:	**13**
				Approved By:	**MAS**

SOP Section	Change
Add 4.6	Interference from calibration standards may result if high level standards are left on the sampling system and open during analysis of low level client samples. SIM samples and SCAN level standards shall never be on the same instrument at the same time.
Add to Section 10	Analysis of SIM samples with any SCAN level standards attached to the concentrator system is not acceptable and may result in low level contamination of client samples.

CH2MHILL
Applied Sciences Laboratory (ASL)

SOP Change Form

☐	Temporary Change	**Analytical Batch/SDG:**	**NA**	**Date:**	**02/24/12**
☒	Permanent Change	**Effective Date:**	**02/24/12**	**SOP No.:**	**AIR12**
				SOP Current Rev.:	**13**
				Approved By:	**MAS**

SOP Section	Change
8.1.1.1	Primary standard: 62 component mix from Scotty, part number 41973-U, 100ppbv concentration.
8.1.1.2	Second source standard: 65 component mix from Restek, part number 34436, 1000ppbv concentration.
LOD and LOQ	Quarterly LOD or LOQs shall not be analyzed for GCMS-R unless workload necessitates this system be used for samples. LOD and LOQ shall continue to be analyzed annually on GCMS-R, and the two remaining systems will maintain quarterly LOD and LOQs.

ANALYTICAL METHOD FOR THE DETERMINATION OF VOLATILE ORGANICS IN AIR BY METHOD TO-14A / TO-15 USING CANISTERS AND GC/MS IN SCAN OR SIM MODE

1.0 SCOPE AND APPLICATION

This document provides standard operating procedures for running Methods TO-14A and TO-15 by gas chromatograph/mass spectrometer (GC/MS) in SCAN and SIM mode at CH2M HILL's Applied Sciences Laboratory in Corvallis, Oregon. These procedures are based upon EPA Method TO-14A and TO-15 as published in "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air", Second Edition, January 1999 and the AFCEE QAPP, Version 3.1 & 4.0.

This method is applicable to specific Volatile Organic Compounds (VOCs) that have been tested and determined to be stable when stored in pressurized and subambient pressure canisters.

2.0 OVERVIEW OF THE ANALYTICAL PROCESS

2.1 Client samples are collected in various formats-Summa canisters, Tedlar® bags, or other similar, but proven, alternatives.

2.2 If necessary, or as requested, samples may be screened using a variety of other techniques such as ECD, FID, or PID detection schemes (depending on the analyte list) to maximize sample throughput and minimize turn around times.

2.3 Samples are pressurized as necessary, depending on other analyses being performed, the sample canister type and the reporting limits required for each analyte.

2.4 Samples are introduced into the GC/MS system by way of a sample concentrator. The concentrator cryogenically traps the sample onto a glass bead or adsorbent trap which allows atmospheric gases to pass through (CO2, O2, N2, etc).

2.5 The glass bead trap is heated and the analytes are transferred to a cryo-focuser module. The focusing module is rapidly heated and the analytes are transferred to the GC column, ultimately traveling to the MS detector.

2.6 The data is collected on a computer that is attached to the GC/MS system and which allows calibration, data processing, reporting of samples, and data archiving.

2.7 SIM and SCAN-The MS system is capable of operating in SCAN or SIM mode, depending on analytical or specific project requirements.

2.7.1 SCAN mode is used for more conventional TO-14A and TO-15 analysis where ppbv levels of detection are required or tentatively identified compounds (TIC) are requested. In this mode the MS scans a range of ions (typically 35-250 amu). This range contains all ions necessary to identify and quantitate all compounds in the TO-14A & TO-15 list.

2.7.2 SIM mode is utilized when reporting limits in the pptv range are requested. In SIM mode, the analyzer only looks at ions specific to the target compounds. Up to three ions are used per compound, 1 for quantitation, and 1 or 2 for qualification. This allows more time to be spent by the analyzer on each ion, which increases sensitivity at the cost of selectivity. Because of this, it is not possible to produce TIC reports or perform a BFB tune check in SIM mode.

2.8 After samples are analyzed, processed, and meet all acceptance criteria herein, a client report is generated and reviewed by a peer. The report may also be reviewed by the QA officer as required by a specific project.

3.0 TARGET ANALYTES, REPORTING LIMITS, AND DETECTION LIMITS

Standard target analytes and reporting limits for analysis in SCAN mode are listed in Table 2. Reporting limits in SIM mode are project-specific, and are typically 50-1000 times lower than SCAN reporting limits.

3.1 The method detection limit (MDL) is defined as the minimum concentration that can be measured and reported within a 99 percent confidence limit that the reported value is above zero. All MDL studies will be performed following ASL SOP14, which refers to 40 CFR 136, App. B as an applicable source method.

3.2 The reporting limits (RL) shall be the lowest calibrated point on the initial calibration curve. This limit may be raised to meet project requirements. Any results that fall between the RL and the MDL shall be qualified as estimated indicating the variability associated with the result. Reporting limits may increase due to dilution factors associated with pressurization of the canisters. Typically achievable limits are as follows and are analyte dependent:

3.2.1 High level Scan : 1.0 ppbv

3.2.2 SIM Mode: 20 pptv

4.0 INTERFERENCES

4.1 Contamination may occur in the sampling system if canisters are not properly cleaned before use. Therefore, canisters are cleaned and certified (See AIR24) before each use. Canisters that are to be used for SIM analysis are certified by TO15 SIM to meet project specific limits-each client requires different levels of certification and the LPM shall be consulted for each low level or SIM project. Refer to AIR06 (SCAN cleaning) or AIR15 (SIM level cleaning) for more information.

4.2 Contamination may occur from impurities in the dilution and carrier gases and from the pump, flow controllers, and solvent vapors in the laboratory. These sources of contamination are monitored through analysis of method blanks.

4.3 Cross-contamination can occur whenever samples containing high VOC concentrations are analyzed. Therefore, whenever an unusually concentrated sample is encountered, the analyst uses professional judgment when reviewing the following samples to determine whether reanalysis is necessary.

4.4 Low-level standard carryover (<1 ppbv) may occur with the Entech autosampler when a highly pressurized calibration standard is connected to the standard port on the back of the concentrator while samples or blanks are being run on the sample tree. Standards should be removed from the system prior to running method blanks or samples as a precaution. This problem has been minimized with regular maintenance of the 6 and 8 port valves in the Entech system, but it is still a recommended practice to remove the standard while running samples. As an added precaution, the line can be capped when not in use to minimize contamination from ambient air.

4.5 The surrogate bromofluorobenzene should be set up with the 174 m/z ion as the primary ion and the 95m/z ion as a qualifier due to the susceptibility of ion 95 to interference from petroleum hydrocarbons.

5.0 SAFETY, WASTE MINIMIZATION, AND POLLUTION PREVENTION

5.1 All samples should be considered hazardous. Samples may include flammables, explosives, and potentially carcinogenic compounds. Air samples may contain analytes outside of the normal list of analytes within this method.

5.2 All stock and working calibration standards, as well as all samples, shall be handled with the utmost care using good laboratory techniques in order to avoid harmful exposure.

5.3 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous.

5.4 The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.5 Personnel are encouraged to review the Chemical Hygiene Plan for general safety policies and Material Safety Data Sheets for reagents and standards used in the laboratory.

5.6 Static dilution stock standards and samples shall be prepared in a fume hood with adequate skin, eye, and hearing protection provided for and used by the analysts. Any situation creating detectable odor levels should be immediately corrected.

5.7 Safety equipment including fire extinguisher, first aid kit, eye wash, and chemical spill cleanup kit shall be available for use at all times.

5.8 Laboratory wastes shall be separated and properly disposed complying with all federal, state, and local regulations. All hazardous wastes shall be handled according to HAZ01, Waste Disposal.

5.9 Analysts are encouraged to reduce the amount of solvent or disposable labware waste whenever possible. More information on this topic can be found in "Less is Better: Laboratory Chemical Management Waste Reduction" from the American Chemical Society.

6.0 SAMPLE COLLECTION, STORAGE, HOLDING TIMES, AND PRESERVATION

6.1 Prior to field sampling, SUMMA® steel canisters are cleaned, certified, and tested for leaks. Canisters are cleaned by alternate pressurization and evacuation during heating (see ASL SOP AIR06 for cleaning). After cleaning, the canisters are certified by EPA method TO-12 (see Canister Certification by Method TO-12, ASL SOP AIR07), by GC/MS method TO-15 (this SOP) or by GC/MS method TO-15 SIM (this SOP).

6.2 Samples are collected and stored in SUMMA® canisters or Tedlar® bags.

6.3 Each canister received by the laboratory is checked for its overall condition. After the canister has been logged into the LIMS system and internal chain of custody via the barcode scanner, the pressure is checked with a pressure transducer. The canister valve is opened briefly and the pressure is recorded in the initial air dilution template.

6.4 Canisters that contain samples requiring dilutions will be pressurized following the canister pressurization procedure in AIR11. Pressures and dilution factors are recorded after pressurization in the air toxics database/Excel file

6.5 The samples are stored in a secure laboratory area. There are no written method requirements for holding times for TO-14A or TO-15 analysis. However, as the TO-15 method does state: "Most VOCs can be recovered from canisters near their original concentrations after storage times of up to 30 days",

6.6 ASL will default to 30 days as the standard holding time for all clients unless specified by that client. Every effort should be made to analyze all samples within 14 days of validated time of sample receipt to meet ASL's standard turnaround times.

6.7 Tedlar® Bag holding times are significantly shorter, although not specifically called out in method TO-14A or TO-15. ASL will minimize the holding time of Tedlar® bags whenever possible to minimize analyte loss. Any bag samples analyzed outside of 14 days from sample collection should be noted in the case narrative.

6.8 Samples are retained until analytical results have undergone a senior data review. After this process, the canisters are transferred to the cleaning area, held for 10 days, evacuated and cleaned as described in section 6.1. Sample canisters may be cleaned sooner if they are needed for other projects, provided the LPM has given approval.

7.0 APPARATUS AND MATERIALS

7.1 All purchasing of apparatus, materials, standards, gases, and reagents will be completed according to the SOP on Purchasing and Receipt of Standards and Reagents SOP31.

7.2 Support equipment and instrumentation utilized in this SOP and requiring metrological compliance either on an annual or quarterly basis can be found listed in the Metrology and Equipment Verification matrix.

7.3 ASL has three analytical systems for TO-14A & TO-15 analysis. The systems are as follows:

7.3.1 System 1 (GCMS-R) - HP5890/5972 GC/MS coupled with Entech 7100A sample concentrator and 16 can sample tree. This system is utilized for TO-14A / TO-15 SCAN work.

7.3.2 System 2 (GCMS-G) - Agilent6890/5973 GC/MS coupled with a Tekmar® Autocan sample concentrator system which includes a 16 can sample tree. This system is used for TO-14A / TO-15 SCAN and TO-15 SIM work.

7.3.3 System 3 (GCMS-AA) – Agilent7890A/5975C GC/MS coupled with a Tekmar® Autocan[12] sample concentrator system which includes a 16 can sample tree. This system is used for TO-14A / TO-15 SCAN and TO-15 SIM work.

7.4 Analytical Traps are as follows:

7.4.1 The Entech system (7.1.1) utilizes two trapping systems, one for water removal and one for analytical standard trapping. The water removal trap (Trap #1) contains glass beads, the analytical trap (Trap #2) contains 100% Tenax. Both are ordered from Entech when replacement is needed.

7.4.2 Tekmar system #2 (7.1.2) utilizes a 6" trap with three stationary phases: Carbopack B, Carbopack C, and Carboxen 1000. This trap is re-packed in house when required following the procedure outlined in Appendix A.

7.4.2.1 Suitable replacement traps in the 6" variety have not yet been found and must be packed in house.

7.4.3 Tekmar system #3 (7.1.3) utilizes a 12" trap with three stationary phases: Carbopack B, Carbopack C, and Carboxen 1000. This trap is re-packed in house when required following the procedure outlined in Appendix A.

7.4.3.1 Suitable replacement traps for the 12" Autocan model may also be ordered from Supelco (Sigma-Aldrich) that come pre-packed. The proper trap to use is a Vocarb 3000 made for the Tekmar Velocity P&T system, part number 5188-2795 from Agilent. The Vocarb 4000 trap may also be used, part number 5188-2796.

7.5 GC Column – Each system is fitted with a ZB-624 60m x 0.25mm capillary column or equivalent.

7.6 Summa canisters - 6L, 5.4L, 1000mL, and 850mL sizes (or equivalent).

7.7 Tedlar® bags in various sizes as needed.

7.8 Gastite® syringes in various sizes from 25uL to 100mL with Teflon plunger and rounded needle tip.

7.9 Static dilution bottle and associated pieces for preparation of custom standards.

7.10 Each GC/MS is interfaced to a personal computer. The computer utilizes the Agilent ChemStation and Enviroquant software for acquisition, integration, quantitation, and storage of mass spectral data.

7.11 Each concentrator and sample tree system uses its own software for control; refer to the manufacturer website for more details.

8.0 STANDARDS, GASES, AND REAGENTS

All standards are logged into the chemical inventory database upon receipt. Any standard that is prepared in the laboratory shall be verified against current standards, or in the case of calibration standards against a second source calibration verification standard, prior to use. This verification shall be recorded in the standard logbook.

Table 4 lists the target compound list (TCL), surrogate, and internal standard compounds and their respective concentrations.

8.1 SCAN mode calibration standards

8.1.1 Stock standards - standards are purchased as custom made mixtures in gas cylinders. Cylinders purchased from vendors are traceable to a National Institute of Standards and Technology (NIST) Standard Reference Material (SRM).

8.1.1.1 Primary standard: 64-component mixture from Restek (part number 34436) which is recertified every 12 months. This standard is 1000ppbv.

8.1.1.2 Second source standard: 62-component mixture from Scott Gases (catalog number 41973-U), which is recertified (manufacturer's specifications) every 12 months. Stock standard is 100ppbv.

8.1.2 Supplemental list standards -When stock standards are not commercially available, standards are prepared in house using pure neat compounds and a static dilution bottle (AIR24, Preparation of Supplemental Standards).

8.1.3 Scan mode calibration standards – Two standards are required for a calibration of all analytes; the 62 component list standard and a supplememental standard, which is dependent on the analyte list required.

8.1.3.1 Primary Calibration Standard –A certified summa can is evacuated and humidified with 50uL of organics free water and pressurized with exactly 228 Torr of the primary standard (section 8.1.1.1) by direct connection through a regulator to the standard cylinder. The canister is then pressurized to 2280 Torr with UHP nitrogen. This 100ppbv standard is valid for 2 months or until it repeatedly fails to meet acceptance criteria.

8.1.3.2 Second Source Calibration Standard –A cleaned, certified summa can is humidified with 50uL of organics free water and pressurized with exactly 228 Torr of the second source standard (section 8.1.1.2) by direct connection through a regulator to the standard cylinder. The canister is then pressurized to 2280 Torr with UHP nitrogen. This 100ppbv standard is valid for 2 months or until it repeatedly fails to meet acceptance criteria.

8.1.3.3 Supplemental standard – After creating a static dilution bottle containing the analytes of interest as in section 8.1.2, an aliquot is drawn into a heated syringe and injected into a certified, evacuated 6L or 5.4L Summa canister that has been humidified with 50uL of organics free water. The canister is pressurized to exactly

2280 Torr with nitrogen. The concentration of each analyte can be calculated by entering the required information into the controlled form SDB Template. Standards prepared in this way are valid for 2 months or until they repeatedly fail to meet acceptance criteria.

8.1.3.4 "All-in-One" standards – To minimize canister use and simplify calibration runs, making a single standard containing all analytes of interest is suggested. This can be created by following the procedure in section 8.1.3.3 and pressurizing the standard with primary or second source stock (instead of nitrogen). These standards are made on an as needed basis and the recipe may change depending on the analyte list, concentrations required, and reporting limits needed. Standards prepared in this way are valid for 2 months or until they repeatedly fail to meet acceptance criteria.

8.2 SCAN mode internal standards and surrogate standards

8.2.1 Scan level internal standard/surrogate – The internal standard/surrogate mix is purchased as a custom made mixture in a gas cylinder (50.0 ppbv for internal standards and surrogates). Each cylinder is prepared with bromochloromethane, 1,4-difluorobenzene, toluene-d8, chlorobenzene-d5, and bromofluorobenzene with nitrogen as the balance gas. Cylinders purchased from vendors are traceable to a National Institute of Standards and Technology (NIST) Standard Reference Material (SRM). The standard expires 7 years from its manufacture date.

8.2.1.1 Each instrument has a dedicated canister for internal standards/surrogates. Surrogate and internal standards are prepared by the following procedure using clean canisters:

8.2.1.1.1 Fill the canister with UHP nitrogen and evacuate to below 100 Torr. Repeat at least two times. Evacuate the can to below 20 Torr after the final rinse.

8.2.1.1.2 Fill the canister with stock standard to a pressure of 50 psig (65 psia) resulting in ~50 ppbv standard. IMPORTANT! Do not expose the pressure transducer to pressures greater than 40 psig. Use the outlet gauge on the regulator to measure the desired pressure. This standard is good until the expiration of the stock which is 7 years from when it was made.

8.3 SIM mode calibration standards

8.3.1 Primary calibration standard (SIM)- This standard is made from the scan mode calibration standard in section 8.1.3.1 and diluted to a final concentration of between 25-5000 pptv depending on the calibration scheme and reporting limits to be used. All dilutions of working standards will have the same expiration date as the parent standards.

8.3.1.1 Primary SIM standard - To create the proper dilution from a 100 ppbv standard inject 50uL of organics free water into a certified, evacuated 6L or 5.4L Summa canister. Transfer 100 Torr of the primary standard into the can using a T-connector on the transducer manifold. Pressurize the can to 2000 Torr. This is effectively a 1:20 dilution producing a standard with a concentration of 5 ppbv. Further dilutions can be prepared in the same manner from this standard as needed.

8.3.1.2 Second source SIM standard – Prepared from standards in section 8.1.3.2 and diluted to 5 ppbv in a Summa canister as above.

8.3.1.3 When calibration standards are not commercially available as in the case of special analyte lists, standards are prepared in house using pure neat compounds (Air24, Preparation of Supplemental Standards). Standards are prepared at concentrations at or near 100pptv depending on analyte and RL requirements.

8.4 SIM mode internal standards and surrogate standards

8.4.1 SIM level internal standard/surrogate - The internal standard/surrogate mix is purchased as a custom made mixture in a gas cylinder, and is the same standard as described in section 8.2.1.

8.4.2 Each instrument has a dedicated canister for internal standards/surrogates. SIM level surrogate and internal standards are prepared by the following procedure using clean canisters:

8.4.2.1 Evacuate the 15L canister to below 100 Torr and fill with nitrogen. Repeat twice and evacuate the canister to below 50 Torr.

8.4.2.2 Using the pressure transducer add 134 torr of 50 ppbv IS/SS stock standard and pressurize the can to 50 psig (65 psia) with UHP nitrogen. A standard prepared in this way will have a final concentration of 2 ppbv. This standard is good for 6 months..

8.5 The surrogate compound bromofluorobenzene is also used as the instrument performance check standard when running in SCAN mode (the tune check compound).

8.6 Gases

The following gases are used as blanks, carrier gas, and cryogen, respectively:

8.6.1 Nitrogen – Ultra High Purity (UHP) 99.999% or "Built in Purifier" (BIP) type, if necessary to meet low levels

8.6.2 Helium – UHP 99.999%

8.6.3 Liquid Nitrogen – cryogenic cooling of the concentrator module(s).

8.7 Neat materials - purchased as required for project specific analyte lists which are prepared in a static dilution bottle. See ASL SOP AIR24, Preparation of Supplemental Standards.

9.0 QA/QC

All reporting limits, QC frequency, and QC acceptance criteria are subject to change on a client specific basis as requested by the client.

9.1 The instrument is tuned using Perfluorotributylamine (PFTBA)-this is generally only performed after MS cleaning and prior to instrument calibration. When tuning the 5972MS use the maximum sensitivity autotune and save it as BFB.u in C:\hpchem\5972 when the tune is completed. Print off a copy of the tune for future reference.

9.1.1 When tuning the 5973 Network MS use the BFB tune and save as bfb.u in C:\MSDChem\mssetup\5973 when the tune is complete. Print off a copy of the tune for future reference.

9.1.2 When tuning the 5975C Inert MSD use the BFB dynamic target tune and save it as bfb.u in C:\MSDChem\mssetup\5975.

9.1.3 Tune evaluation

9.1.3.1 The EM volts and repeller should have similar results to the most recent tune, but will vary slightly. Beyond a 10% change in values, it's a good idea to look carefully at all parameters before continuing.

9.1.3.2 There should be minimal or no air leak-check this by looking at the ions at 28 (N2), 32 (O2), and 44 (CO2) -the ratio of these ions to ion 69 should be below 10% for nitrogen and below 5% for oxygen and CO2.

9.1.3.3 The ISO Ratio should be close to 1 for mass 69, 4-5 for mass 219, and 9-11 for mass 502.

9.2 When running in SCAN mode for ASL standard clients and AFCEE 4.0.01 clients, the tune is checked every 24 hours using bromofluorobenzene (BFB). . If tune criteria can not be met (see Table 1), then a MS hardware tune must be performed. If criteria are still not met after re-tuning, then it may be necessary to clean the source. All maintenance shall be recorded in the instrument log book.

9.2.1 The tune is evaluated by averaging the apical scan of the BFB peak with the two scans on either side of it, and then background subtracting one scan from before the BFB peak. The tune file is generated by the data analysis software using the "Tuner" menu.

9.2.2 On some systems, spectral averaging produces bad data due to small shifts in m/z assignments between scans. In these cases a single scan at greater than half peak height may be used for tune evaluation. Evaluation criteria can be found in Table 1.

9.3 Initial Calibration

An initial calibration curve is required to demonstrate adequate instrument performance for sensitivity, linearity, resolution, and freedom from active sites.

9.3.1 A valid initial calibration curve must be established before any samples can be analyzed. The GC/MS is calibrated following the outline, below. Variations from this are sometimes necessary because of reporting limits, but this is the standard scheme.

9.3.2 As the reporting limit is driven by the lowest calibration point, any lowering of the RL will require either A) calibrating to a lower level of B) injection of more sample volume.

9.3.3 Calibration Schemes

The following calibration schemes have been successfully used at ASL, the actual scheme used should be tailored to the instrument and project requirements.

High range SCAN Cal Levels (250mL normalization-System 1, 2 and 3)

Cal level - SCAN	Std Concentration, ppbv	Std Volume, (mL)	Concentration, ppbv
Level 1	5.0	25	0.50
Level 2	5.0	50	1.0
Level 3	5.0	250	5.0
Level 4	100	50	20
Level 5	100	75	30
Level 6	100	125	50
Level 7	100	250	100

Low range SCAN Cal Levels (500mL normalization, System 3 – Tekmar and 6890/7890 and 5973MS)

Cal level - SCAN	Std Concentration, pptv	Std Volume, (mL)	Concentration, pptv
Level 1	50	100	10
Level 2	50	200	20
Level 3	50	500	50
Level 4	5,000 (5ppbv)	50	500
Level 5	5,000 (5ppbv)	250	2,500
Level 6	100,000 (100ppbv)	50	10,000
Level 7	100,000 (100ppbv)	100	20,000

SIM Cal Levels (1000mL normalization – System 2 or 3 Tekmar and 6890/7890 and 5973MS)

Cal level - SIM	Std Concentration, pptv	Std Volume, (mL)	Concentration, pptv
Level 1	50	80	4
Level 2	50	200	10
Level 3	500	40	20
Level 4	500	100	50
Level 5	500	500	250
Level 6	5000	100	500
Level 7	5000	400	2000
Level 8	5000	1000	5000

9.3.4 For the initial calibration a relative response factor (RRF), a relative retention time (RRT), a mean relative response factor, and a percent relative standard deviation are calculated for each analyte. The equations for calculating these are shown in section 11.0, Data Reduction. The RRT for each target compound must be within 0.06 RRT units of the mean RRT for that compound. The area response of the internal standards must not vary by more than ±40% from the mean for any calibration level (Equations 1, 2, 5, and 6).

9.3.5 The retention time shift of the internal standards at each calibration level must be within 20 seconds of the mean retention time over the initial calibration range for each internal standard.

9.3.6 After a new calibration is performed the method needs to be saved with the correct filename. The method name should be the date followed by the instrument letter. For example, an ICAL performed on October 29 on GCMS-R shall be named 102909R.

9.3.7 Non-AFCEE

9.3.7.1 SCAN - The %RSD for all compounds must be less than 30%. Up to two compounds may exceed 30 percent but may not exceed 40 %RSD (Equation 4).

9.3.7.2 SIM - The average response factor must be less than 30% for all analytes. Other calibrations (e.g. linear) may be used only if the project QAP or project manager allows it (Equation 4).

9.3.8 AFCEE – The requirement is <30% RSD for all compounds. No compounds may exceed this limit. Linear fit calibration may be used for AFCEE 4.0, but should be verified with the LPM prior to its use.

9.3.9 Every curve should be validated against project specific criteria before analyzing samples; there are instances that do not fit into the AFCEE or non-AFCEE requirements listed above. Check the project file or associated QAPP first, and then with the project manager if further clarification is required.

9.3.10 If the above requirements are not met, then a new initial calibration must be performed. If this does not result in an acceptable initial calibration then system maintenance may be necessary.

9.3.11 Calibrations are valid for one year as long as QC continues to meet acceptance criteria.

9.3.12 In the following instances, a new calibration shall be required:

9.3.12.1 Major instrument maintenance such as cleaning the MS.

9.3.12.2 Repeated failure to pass continued calibration criteria.

9.3.13 If an analyzed sample falls above the calibrated range of the instrument, it must be diluted.

9.4 Initial Calibration Verification (ICV) - A second source standard shall be run at the end of each initial calibration to verify the calibration standard concentrations and accuracy of the calibration curve.

9.4.1 For AFCEE 4.0 and all other samples (unless specified in a project specific QAPP), the %D for each compound must not exceed 30% (Equation 9).

9.4.2 Samples may not be analyzed until an acceptable ICV is run.

9.5 Initial demonstration of capability (IDC) - This study must be performed prior to use of the method by each analyst or after any significant changes to the method. An IDC study consists of four aliquots of standard processed through the entire analytical method.

9.5.1 Prepare and analyze four spiked blank samples that are the same concentration as one of the calibration points, excluding the low and high levels.

9.5.2 Calculate the mean concentration found (X) in ppbv or pptv and the standard deviation of the concentration in ppbv or pptv for each analyte using the controlled form IDC_Template.

9.5.3 For each analyte X should be between 70% and 130% of the true value. The RSD should be 25% or less. If the results from all analytes meet these criteria then the system and analyst performance are acceptable. If any analyte fails to meet the criteria then investigate and correct the source of the problem and repeat the test (Equation 9).

9.6 Method Blanks – method blanks are required at a rate of one per batch or one every 24 hours, whichever comes first. Some clients require a blank every 12 hours, make sure to verify with the LPM. Method blanks are analyzed to monitor possible laboratory contamination. Laboratory method blanks are prepared with UHP nitrogen in a 6 liter canister every day samples are to be analyzed. The method blank is carried through the same analytical procedure as a field sample and contains the same amount of surrogate and internal standard that are added to each sample.

9.6.1 Method blanks are analyzed by injecting the full normalized volume of nitrogen (varies by system) into the pre-concentrator and following procedures outlined in section 10.

9.6.2 The blank must not contain any target analyte at a concentration greater than the RL and must not contain additional compounds with elution characteristics and mass spectral features that would interfere with identification and measurement of a method analyte at its MDL. Generally, the blank concentration should be less than 5 times the project required reporting limit or less than the MDL, whichever is greater. AFCEE requires that the blank be less than the ½ of the reporting limit. If target analytes are found in the method blank above the reporting limit, the source of the contamination must be considered. Usually, re-running the blank will clear up most problems (especially if the sample run prior to the blank was high in target analyte concentration.) If blank contamination is still present, the analyst should perform system maintenance. Some common problems that cause a blank to show contamination are:

9.6.2.1 Cold spots - check heated zones for failure.

9.6.2.2 Low pressure in the blank sample canister - flush and refill the canister.

9.6.2.3 Leaky valves - check all concentrator valves for spindle scoring.

9.6.2.4 Buildup of methylene chloride in the room from extract vials. Dead samples and waste should be stored in sealed containers and disposed of on a regular basis.

9.6.2.5 High pressure calibration standard open to the system – remove all calibration standards from the instrument prior to running blanks and samples.

9.6.3 If the blank contamination cannot be resolved with a fresh blank or system maintenance, contact the LPM for approval. A new blank should always be attempted before reporting a blank with qualifiers. If approved by the LPM, the issue should be explained in the case narrative.

9.7 Continuing Calibration Verifications (CCV) – a primary source standard analyzed at the beginning of an analytical batch to ensure that the instrument continues to meet the instrument sensitivity and linearity requirements originally established by the initial calibration.

9.7.1 The opening calibration verification for each compound of interest shall be verified prior to sample analysis using the same introduction technique and conditions as used for samples. This is accomplished by analyzing one of the calibration standards used for initial calibration.

9.7.1.1 Typical concentrations for calibration verification are at or below the midpoint of the instrument calibration curve.

9.7.2 No closing calibration check is required for TO-14A/15 analysis. An acceptable calibration check standard run is good for 24 hours or 20 samples, whichever comes first.

9.7.3 The %D for each compound may not exceed 30 percent (Equation 9).

9.7.3.1

9.7.4 Failure to pass continuing calibration criteria requires reanalysis of the affected samples after evaluation of the system and corrective action are performed. Repeated failure to pass response factor criteria requires the performance of a new initial calibration.

9.8 Laboratory control sample (LCS) - a laboratory control sample is analyzed once per analytical batch to determine if the entire method is in control.

9.8.1 The LCS shall be a volume of the primary calibration standard injected at or below the midpoint of the calibration curve for each midpoint. The LCS shall be carried through the complete analytical procedure.

9.8.1.1 Standard LCS recovery limits are 70-130% of the expected value (Equation 9).

9.8.1.2 For AFCEE the %D for each compound may not exceed 25% (Equation 9).

9.8.1.3 A LCS failing to meet acceptance criteria may be re-ran, investigated and fixed, or given consent of the project manager. Approval of the project manager results in failing analytes reported with qualifiers and explanation in the case narrative.

9.9 Duplicates - analysis of a duplicate is performed to determine precision. This is determined by comparing two replicates of a randomly selected sample and expressing the results as a percentage (Equation 10).

9.9.1 Duplicates will be analyzed on 5% or more (1 in 20) of the samples analyzed. A duplicate must be included in every analytical batch.

9.9.2 Laboratory duplicate samples should be chosen randomly from a client batch of samples unless they are pre-selected by the client. Analysts should rotate the client selected for laboratory duplicates so that precision data is collected from a wide variety of sample matrices.

9.9.3 Acceptable precision will be less than 25%RPD (standard lab limit and AFCEE 4.0). A controlled form TO15 RPD CALC must be used for calculating the RPD for LL and Scan samples (Equation 10).

9.9.4 If duplicate results fail to meet acceptance criteria then the LPM must be notified and this exception must be noted in the case narrative of the final report. If a duplicate fails due to obvious system or operator error, the duplicate should be re-analyzed one time for verification.

9.10 Internal standards – Internal standards are added to all QC and field samples to correct for analytical variability. Three ISTD compounds, bromochloromethane, 1,4-difluorobenzene and chlorobenzene-d5, are added to each field and QC sample at a nominal concentration of 10ppbv in SCAN mode and 100pptv in SIM mode.

9.10.1 For AFCEE 4.0 and ASL standard lab limits, an acceptable internal standard will recover between 60-140% of the internal standard area in the most recent continuing calibration.

9.10.2 The retention time of any ISTD compound may not change more than 30 seconds from the latest continuing calibration.

9.10.3 Specific projects may have different ISTD criteria, verify each project's QAP prior to sample analysis. When ISTD results do not meet acceptance criteria, corrective action shall be performed and samples reanalyzed. If no sample is left to analyze, discuss with the LPM for the proper course of action.

9.11 Surrogates - Toluene-d8 and bromofluorobenzene are added to all QC and field samples. The surrogate recoveries must be 70-130%. If surrogate recoveries are outside of acceptance criteria then the sample will be reanalyzed. If reanalysis does not fix the problem then it is up to the analyst to decide if the problem is a matrix interference or a system error. If the problem is a matrix interference then it should be noted on the case narrative. If the problem is a system error then corrective action should be taken and sample analysis stopped until the problem is fixed (Equation 9).

9.12 Method detection limits (MDL) - The MDL study is performed initially at method validation and any time instrument changes/modifications affect the detection limits significantly. MDLs must be less than or equal to one half of the reporting limit (the lowest calibration level). See SOP14 for MDL generation details.

Limit of detection/Limit of quantitation (LOD/LOQ) - The LOD/LOQ study must be performed in accordance with SOP32. The LOD acceptance criteria are met when the analyte is detected at 3 times the signal to noise ratio. The LOQ acceptance criteria shall be the same as those for an LCS plus 15% of the upper control limit (UCL) and minus 15% of the lower control limit (LCL). This study should be performed immediately after the MDL study.

9.13 Any item from this list that does not meet acceptance criteria needs to be clearly documented on a corrective action form and submitted to the QA officer. The problem(s) should be fixed and the instrument shown to run properly before any further analysis is performed. Failing QC parameters such as surrogate failures, or blank spike/matrix spike failures will require communication with the laboratory project manager, as well as a corrective action report. Samples may need to be re-analyzed depending on project requirements. For each failure to meet the acceptance criteria above, the laboratory project manager should be consulted to determine the proper course of action via contact with the client.

9.14 Uncertainty - The uncertainty of measurements shall be calculated by following SOP30.

9.15 Sources of Error –

9.15.1 The major source of error may arise in the concentrator system. The sample concentration process requires a clean system with optimally operating components in place along the sample pathway. This requires constant and vigilant maintenance of all systems.

9.15.2 Improper preparation of static dilution bottle for primary and secondary standards along with the preparation of primary and secondary cocktail solutions. In most cases this can be verified with multiple sources of standards.

9.15.3 Miscalculating dilutions for samples or injecting the incorrect amount of standard or sample via the auto-can. An uncalibrated mass flow-controller may be the issue.

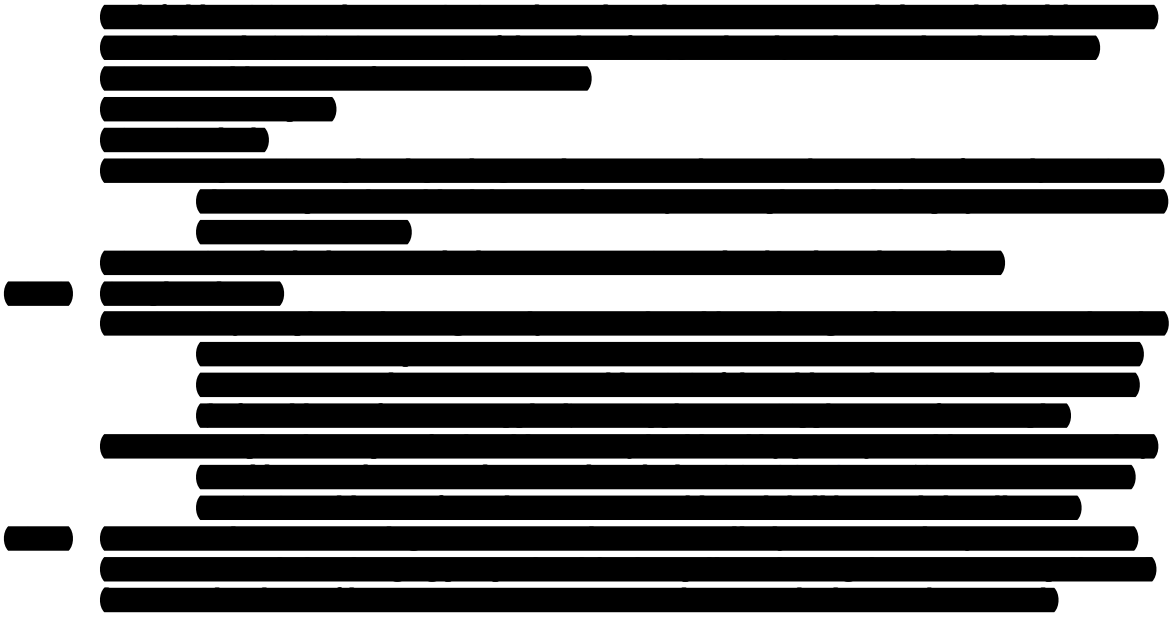
9.15.4 Using the incorrect GC/MS or auto-can method.

10.0 PROCEDURE

10.1 [redacted]

10.4 [redacted]

10.6.5 [redacted]



11.0 DATA REDUCTION

11.1 Calculations

11.1.1 Relative response factor: For the initial calibration, a relative response factor (RRF) is calculated for each analyte in each concentration level. The RRF is the ratio of amount of analyte in the compound to the amount of internal standard injected. The formula for calculating the RRF is shown in equation 1.

$$RRF = \frac{AxCis}{AisCx} \qquad \text{equation 1}$$

Where: RRF = relative response factor
Ax = area of the primary ion for the compound to measured.
Ais = area of the primary ion for the internal standard
Cis = concentration of internal standard spiking mixture (ppbv)
Cx = concentration of the compound in the calibration standard (ppbv)

11.1.2 Mean Relative response factor: Based on the RRFs calculated in equation 1, a mean relative response factor for each analyte is calculated. The mean RRF is the average of all RRFs for an analyte. The formula for calculating the mean RRF is shown in equation 2.

$$\overline{RRF} = \sum_{i=1}^{n} \frac{Xi}{n} \qquad \text{equation 2}$$

Where: $\overline{RRF}$ = mean relative response factor
Xi = RRF of the compound
n = number of points in the curve

11.1.3 Percent Relative Standard Deviation (%RSD): Based on results from equations 1 and 2 above, the percent relative standard deviation (%RSD) is calculated for each analyte. The %RSD is the ratio of the standard deviation (SD) of all RRFs for an analyte to the mean RRF for that analyte. The formulas for calculating %RSD and SD is shown in equations 3 and 4.

$$SD_{RRF} = \sqrt{\frac{\sum_{i=1}^{N} (RRFi - \overline{RRF})^2}{N-1}} \qquad \text{equation 3}$$

And

$$\%RSD = \frac{SD_{RRF}}{\overline{RRF}} \times 100 \qquad \text{equation 4}$$

Where: RRF = mean of initial relative response factors (per compound).
SDrrf= standard deviation of initial response factors (per compound)
RRFi= relative response factor at a concentration level
N = number of points in the curve (usually 6)

11.1.4 Relative Retention Times (RRT): Calculate the RRTs for each target compound over the initial calibration range using equation 5.

$$RRT = \frac{RTc}{RTis} \qquad \text{equation 5}$$

Where: RTc = retention time of target compound, seconds
RTis = retention time of internal standard, seconds

11.1.5 Mean of the Relative Retention Times ($\overline{RRT}$): Calculate the mean of the relative retention times for each analyte over the whole calibration using equation 6.

$$\overline{RRT} = \sum_{i=1}^{n} \frac{RRT}{n} \qquad \text{equation 6}$$

Where: $\overline{RRT}$ = Mean relative retention time for the target compound for each initial calibration standard
RRT = Relative retention time for the target compound at each calibration level

The RRT for each target compound at each calibration level must be within 0.06 RRT units of the mean RRT for the compound.

11.1.6 Mean Area Response ($\overline{\mathbf{Y}}$) for Internal Standard: Calculate the mean area response for each internal standard over the whole calibration range using equation 7.

$$\overline{Y} = \sum_{i=1}^{n} \frac{Yi}{n} \qquad \text{equation 7}$$

Where: $\overline{Y}$ = Mean area response
Y = Area response for the primary quantitation ion for the internal standard for each initial calibration standard

The area response Y of each calibration level must be within the 40% of the mean response $\overline{Y}$ of the whole calibration.

11.1.7 Mean Retention Times ($\overline{\mathbf{RT}}$): Calculate the mean retention times for each internal standard over the initial calibration range using equation 8.

$$\overline{RT} = \sum_{i=1}^{n} \frac{RTi}{n} \qquad \text{equation 8}$$

Where: $\overline{\mathbf{RT}}$ = Mean retention time, seconds
RT = Retention time for the internal standard for each initial calibration, seconds.

11.1.8 For the second source calibration verification, continuing calibration, LCS and ISTD a percent difference (%D) is calculated. For example, the %D is the ratio of the difference between the RRF in the continuing calibration and the mean RRF in the initial calibration. The formula for calculating %D is shown in equation 9.

$$\%D = \frac{RRFc - \overline{RRFi}}{\overline{RRFi}} x100 \qquad \text{equation 9}$$

Where: $\overline{RRFi}$ = mean RRF of the compound in the most recent initial calibration.
RRFc= RRF of the compound in the continuing calibration standard

11.1.9 Duplicate analysis is performed to determine precision. This is determined by comparing two replicates of the same sample and expressing the results as a percentage.

$$\%RPD = \frac{|X - Y|}{(X + Y)} x200 \qquad \text{equation 10}$$

Where: X = first measured value
Y = second measured value

11.1.10 Surrogate recovery (%REC):

$$\%REC = \frac{\text{observed value}}{\text{true value}} \times 100$$

11.2 Qualitative Analysis

11.2.1 Client requested compounds should be identified by an analyst competent in the interpretation of mass spectra by comparison of the sample mass spectrum and the spectrum of a standard of the suspected compound. Two criteria must be satisfied to verify the identifications. If either of these criteria are not met, analyst judgement must be used to determine the presence of a compound If it is not possible to confirm the compounds presence, that compound should be reported as a non-detect.

11.2.1.1 Condition #1: elution of the analyte at the same retention time as the corresponding standard component. The RT of each internal standard must be ±0.33 min. from the RT in the most recent calibration check or curve. Target analytes must be ±0.06 RRT units of the RRT of the most recent calibration.

11.2.1.2 Condition #2: correspondence of the sample component and standard component mass spectra. One, two, or three ions are picked for each compound and used as qualifying ions. The relative abundance of these ions to the target ion for that compound are compared to the ratios determined from the initial calibration. All ratios that differ by more than 20% will be automatically flagged on the instrument print out and need to be examined more closely. The analyst should visually examine the spectra and determine if the poor qualifying ratio was caused by interference.

11.2.2 When requested a library search is executed for all non-target sample components for the purpose of tentative identification (SCAN mode only). For this purpose, the most recent release of the NIST spectral library shall be used. Computer generated library search routines that would misrepresent the library or unknown spectra when compared to each other, must not be used. Compounds greater than a reporting limit of 1 times the dilution factor that can be tentatively identified via a library search can be reported, provided the match quality is 50% or greater. Non-target compounds that are identified are referred to as Tentatively Identified Compounds (TIC). TICs are quantified by the internal standard method. TIC concentration is calculated using the formula in equation 11.

$$\text{TIC Concentration} = \frac{AxCisDF}{\overline{AisRRF}} \qquad \text{equation 11}$$

Where: RRF = 1
Ax = area of the TIC peak
Ais = internal standard area for the nearest ISTD
Cis = 10 ppbv (Internal standard concentration)
DF = dilution factor

11.3 Quantitative Analysis

Target Compounds identified are quantified by the internal standard method using the peak area of the characteristic ions of target analytes. The mean relative response factor (RRF) from the initial calibration analysis is used to calculate the concentration in the sample. The equation for determining concentration is shown in equation 12.

$$\text{TC Analyte Concentration} = \frac{AxCisDF}{Ais\overline{RRF}} \qquad \text{equation 12}$$

Where: RRF = mean response factor from the initial calibration.
Ax = area of the characteristic ion for the compound to be measured
Ais = area of the characteristic ion for the specific internal standard
Cis = concentration of the internal standard spiking mixture (ppbv)
DF = dilution factor

12.0 DOCUMENTATION

12.1 Data review and laboratory checklist

Sample data must be reviewed with the associated quality control data. The following checklist should be consulted before releasing sample results.

12.1.1 Valid initial calibration
12.1.2 Valid continuing calibration
12.1.3 Valid tune
12.1.4 Valid method blank
12.1.5 Valid internal standard and surrogate recoveries
12.1.6 Positive samples double checked for interpretation
12.1.7 Results corrected for dilutions
12.1.8 Results adjusted for interferences/chemical noise
12.1.9 Valid qualifying ion ratios
12.1.10 Good chromatography
12.1.11 Valid manual integrations. In the event manual integrations are necessary, the raw data is to be signed by the analyst before any manual integrations; after re-integrating, the raw data must be signed by both the analyst and a peer reviewer (refer to ASL SOP26 for proper manual integration technique). In the case of a calibration or calibration verification sample needing manual integration, the raw data must be signed by the peer reviewer and the QA officer before being considered valid for use.

12.2 Data reporting

12.2.1 Analytical results are summarized from the raw data. The appropriate deliverables are produced using Microsoft Access, Microsoft Excel and Microsoft Word software. Sample results are reported without blank subtraction. TCL concentrations (including the reporting limits) should be reported with a maximum of three significant figures.
12.2.2 The case narrative will summarize any analytical or documentation exceptions along with the quality of the QC results.
12.2.3 All reports are reviewed and signed by a peer before delivery to the client.

12.3 GC/MS data deliverables

12.3.1 Refer to ASL SOP35 and SOP36 for details on using the reporting tools available at the Applied Sciences Lab.
12.3.2 Three different levels of QC documentation are available to meet the needs of the client. Refer to the ASL Quality Assurance Program Manual for details on Level 2, Level 3 and Level 4 deliverables.

13.0 REFERENCES

13.1 *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Method TO-14A, Second Edition*, U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA 600/625/R-96/010b, January 1999.
13.2 *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Method TO-15, Second Edition*, U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA 600/625/R-96/010b, January 1999.
13.3 CH2M HILL Applied Sciences Laboratory standard operating procedures referenced and linked to in this document: ALL SOPs listed within this document.
13.4 AFCEE Quality Assurance Program Plan, Version 3.1 and 4.0.

14.0 DEFINITIONS

14.1 ASL – Applied Sciences Laboratory
14.2 CVO – Corvallis, OR
14.3 NELAC – National Environmental Laboratory Accreditation Conference
14.4 NELAP – National Environmental Laboratory Accreditation Program
14.5 OFW – organic-free water
14.6 QA/QC – Quality Assurance/Quality Control
14.7 QA – Quality Assurance
14.8 QC – Quality Control
14.9 SCAN – Mode of MS operation in which the instruments scans a range of specified ions.
14.10 SIM – Mode of operation in which only specific target compound's ions are scanned
14.11 SOP – Standard Operating Procedure
14.12 IDC – Initial Demonstration of Capability
14.13 RSD – Relative Standard Deviation
14.14 %D – Percent Difference
14.15 LCS – Laboratory Control Standard
14.16 QAP – Quality Assurance Plan
14.17 LCSD – Laboratory Control Standard Duplicate
14.18 Internal Standard (IS) – A pure analyte(s) added to a sample, extract, or standard solution in known amount(s) and used to measure the relative responses of other method analytes and surrogates that are components of the same sample or solution. The internal standard must be an analyte that is not a sample component.
14.19 Surrogate Standard (SS) – A pure analyte(s), which is extremely unlikely to be found in any sample, and which is added to a sample aliquot in known amount(S) before extraction or other processing and is measured with the same procedures used to measure other sample components. The purpose of the SS is to monitor method performance with each sample.
14.20 Laboratory Duplicates (Dup) – Two aliquots of the same sample taken in the laboratory and analyzed separately with identical procedures. Analyses of duplicates indicates precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.
14.21 Field Duplicates (FD) – Two separate samples collected at the same time and place under identical circumstances and treated exactly the same throughout field and laboratory procedure. Analyses of Duplicates gives a measure of the precision associated with sample collection, preservation and storage, as well as with laboratory procedures.
14.22 Laboratory Replicates – An aliquot of sample is taken in the laboratory and prepared. The prepared sample is then analyzed twice. Laboratory replicates indicate precision associated with instrumentation and not sample preparation. For some test methods, a laboratory duplicate and a laboratory replicate may be the same thing.
14.23 Laboratory Reagent Blank (WB1, SB1, XB1) – An aliquot of reagent water or other blank matrix that is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with other samples. The blank is used to determine if method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.
14.24 Trip Blank (TB) – An aliquot of reagent water or other blank matrix that is placed in a sample container in the laboratory and treated as a sample in all respects, including shipment to the sampling site, exposure to sampling site conditions, storage, preservation, and all analytical procedures. The

purpose of the TB is to determine if method analytes or other interferences are present in the field environment.

14.25 Calibration Check Verification (CCV, CCC) – A solution of one or more compounds (analytes, surrogates, internal standard, or other test compounds) used to evaluate the performance of the instrument system with respect to a defined set of method criteria.

14.26 Blank Spike (BS1W, BS1S) – An aliquot of reagent water or other blank matrix to which known quantities of the method analytes are added in the laboratory. The BS is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements.

14.27 Stock Standard Solution (SSS) – A concentrated solution containing one ore more method analytes prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source.

14.28 Primary Standard Solution (PSS) – A solution of several analytes prepared in the laboratory from stock standard solutions and diluted as needed to prepare calibration solutions and other needed analyte solutions.

14.29 Calibration Standard (CAL) – A solution prepared from the primary standard solution or stock standard solution and the internal standards and surrogate analytes. The Cal solutions are used to calibrate the instrument response with respect to analyte concentration.

14.30 Initial Calibration Verification (ICV) – A solution of method analytes of known concentrations which is used to fortify an aliquot of WB1 or sample matrix (MS). The ICV is obtained from a source external to the laboratory and different from the source of calibration standards. It is used to check laboratory performance with externally prepared test materials.

Tables

Table 1: BFB Instrument Performance Check Ion Abundance Criteria

m/e	Ion Abundance Criteria
50	15.0 - 40.0% of m/e 95
75	30.0 - 60.0% of m/e 95
95	Base peak, 100% relative abundance
96	5.0 - 9.0% of m/e 95
173	Less than 2% of m/e 174
174	>50.0 of m/e 95
175	5.0 - 9.0% of m/e 174
176	95.0 - 101.0% of m/e 174
177	5.0 - 9.0% of m/e 176

Table 2: Scan/Sim Method Analytes

Standard Analytes	CAS Number	Typical Scan Level* Reporting limit ppbv
Propylene	115-07-1	1.0
Dichlorodifluoromethane	75-71-8	1.0
Chloromethane	74-87-3	1.0
1,2-Dichloro,1,1,2,2-tetrafluoroethane	76-14-2	1.0
Vinyl chloride	75-01-4	1.0
1,3-butadiene	106-99-0	1.0
Bromomethane	74-83-9	1.0
Chloroethane	75-00-3	1.0
Trichlorofluoromethane	75-69-4	1.0
Ethanol	64-17-5	1.0
Acrolein	107-2-8	1.0
Isopropyl alcohol	67-63-0	1.0
Acetone	67-64-1	1.0
1,1-Dichloroethene	75-35-4	1.0
Methylene chloride	75-09-2	1.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	1.0
Carbon Disulfide	75-15-0	1.0
trans-1,2-Dichloroethene	156-60-5	1.0
Methyl-tert-butyl ether	1634-04-4	1.0
1,1-Dichloroethane	75-34-3	1.0
Vinyl Acetate	108-05-4	1.0
Hexane	110-54-3	1.0
Methyl ethyl ketone	78-93-3	1.0
cis-1,2-Dichloroethene	156-59-2	1.0
Ethyl acetate	141-78-6	1.0
Tetrahydrofuran	109-99-9	1.0
Chloroform	67-66-3	1.0
1,2-Dichloroethane	107-06-2	1.0
1,1,1-Trichloroethane	71-55-6	1.0
Cyclohexane	110-82-7	1.0
Carbon tetrachloride	56-23-5	1.0
Benzene	71-43-2	1.0
Heptane	142-82-5	1.0
1,2-Dichloropropane	78-87-5	1.0
Trichloroethene	79-01-6	1.0
1,4-dioxane	123-91-1	1.0
Bromodichloromethane	75-27-4	1.0
cis-1,3-Dichloropropene	10061-01-5	1.0
Methyl isobutyl ketone	108-10-1	1.0
trans-1,3-Dichloropropene	10061-02-6	1.0
1,1,2-Trichloroethane	79-00-5	1.0
Toluene	108-88-3	1.0
1,2-Dibromoethane	106-93-4	1.0
2-Hexanone	591-78-6	1.0
Tetrachloroethene	127-18-4	1.0

Dibromochloromethane	124-48-1	1.0
Chlorobenzene	108-90-7	1.0
Ethylbenzene	100-41-4	1.0
m,p-Xylenes	108-38-3/1	2.0
Bromoform	75-25-2	1.0
Styrene	100-42-5	1.0
o-Xylene	95-47-6	1.0
1,1,2,2-Tetrachloroethane	79-34-5	1.0
n-propylbenzene	103-65-1	1.0
4-ethyltoluene	622-96-8	1.0
1,3,5-Trimethylbenzene	108-67-8	1.0
1,2,4-Trimethylbenzene	95-63-6	1.0
bis(2-chloroethyl)ether	111-44-4	1.0
Benzyl Chloride	100-44-7	1.0
1,3-Dichlorobenzene	541-73-1	1.0
1,4-Dichlorobenzene	106-46-7	1.0
1,2-Dichlorobenzene	95-50-1	1.0
n-butylbenzene	104-51-8	1.0
bis(2-chloroisopropyl)ether	108-60-1	1.0
1,2,4-Trichlorobenzene	120-82-1	1.0
Hexachlorobutadiene	87-68-3	1.0
Naphthalene	91-20-3	1.0
2-methyl naphthalene	91-57-6	1.0

*RL is after required canister dilution.

Table 3: Typical Stock Standards

Formal Name	CAS #	Merck #	Conc. ppbv
Dichlorodifluoromethane	75-71-8	3048	100
Chloromethane	74-87-3	5918	100
1,2-Dichloro-1,1,2,2-tetrafluoroethane	1320-37-2		100
Vinyl chloride	75-01-4	9796	100
Bromomethane	74-83-9	3720	100
Chloroethane	75-00-3	3729	100
Trichlorofluoromethane	75-69-4	9453	100
1,1-Dichloroethene	75-35-4	9798	100
Methylene Chloride	75-09-2		100
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1		100
1,1-Dichloroethane	75-34-3	3756	100
cis-1,2-Dichloroethene	156-59-2	87	100
Chloroform	67-66-3	2111	100
1,2-Dichloroethane	107-06-2	3743	100
1,1,1-Trichloroethane	71-55-6	449	100
Benzene	71-43-2	1063	100
Carbon Tetrachloride	56-23-5	1799	100
1,2-Dichloropropane	78-87-5	7755	100
Trichloroethylene	79-01-6		100
cis-1,3-Dichloropropene	10061-01-5	3059	100
trans-1,3-Dichloropropene	10061-02-6	3059	100
1,1,2-Trichloroethane	79-06-5	9450	100
Toluene	108-88-3	9357	100
1,2-Dibromoethane	106-93-4	5934	100
Tetrachloroethylene	127-18-4	9017	100
Chlorobenzene	108-90-7	2090	100
Ethylbenzene	100-41-4	3714	100
m,p-Xylene	1330-20-7	9890	200
Styrene	100-42-5	8732	100
1,1,2,2-Tetrachloroethane	79-43-5	9016	100
o-Xylene	95-47-6	9890	100
1,3,5-Trimethylbenzene	108-67-8	5752	100
1,2,4-Trimethylbenzene	95-63-6	7816	100
1,3-Dichlorobenzene	541-73-1	3039	100
1,4-Dichlorobenzene	106-46-7	3041	100
1,2-Dichlorobenzene	95-50-1	3040	100
1,2,4-Trichlorobenzene	120-82-1	9443	100
Hexachlorobutadiene	87-68-3		100

Table 3 Continued:

Formal Name	CAS #	Conc. ppbv
Surrogate		
Toluene-d8	2037-26-5	50
Bromofluorobenzene	460-00-4	50
Internal Standard		
Bromochloromethane	74-97-5	50
1,4-Difluorobenzene	540-36-3	50
Chlorobenzene-d5	3114-55-4	50

Table 4: General GC and MS Operating Conditions

Chromatography	
Column	ZB-624, 60m 0.25 mm I.D. (or equivalent)
Carrier Gas	Helium 1 mL/min – constant flow

Temperature Program			
Initial Temperature	40C		
Initial Time	9.0 min		
Level	Rate (ºC/min)	Final Temp (ºC)	Final Time (min)
1	12	190	0
2	6	255*	0
Total run time – 32.33 (parameters taken from SCAN_RUN1.M, GCMS-AA)			

* Max temp. depends on column used.

Figure 1

AIR TOXICS LABORATORY
INSTRUMENT LOG SHEET
GC/MS-R

LINE No.	DATE	CLIENT	BY	DIRECTORY	LAB ID	CONC. POS.	SAMPLE VOLUME	DF	FIELD ID.	GC/ MS METHOD	ENTECH NAMELIST	COMMENTS
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
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32												

Figure 1. A scanned copy of logbook page. Each logbook is assigned a controlled ID number.

Appendix A

Tekmar Trap Re-packing Procedure

For the 6 inch Trap system connected to GCMS-G, the following trap preparation should be followed

1. Carefully remove the trapping material from an old trap, taking care not to scratch the inside of the tube. Wash the tube with methanol and deionized water and bake it in a 100° C oven for 30 minutes.
2. Insert a 1cm plug of quartz wool in the front of the trap (the end with the 1/8" swage nut is the front, this is the side that samples load into). Leave 2 cm of empty space on the front end.
3. Pour 0.033 grams of Carbopack C (Supelco, part #10257) in the back of the trap and very lightly pack it by tapping on the counter/table. Repeat with 0.057 grams of Carbopack B (Supelco, part #20273).
4. Place a small plug of quartz wool behind the Carbopack B and then load 0.078 grams of Carboxen 1000 (Supelco, part #10478-U) into the trap. Pack lightly. The purpose of the quartz wool plug is to keep the lower-efficiency Carbopack B from mixing with the high-efficiency Carboxen 1000.
5. Place a 1cm plug of quartz wool in the back of the trap. Check to see that there is 2-3cm of empty space left in the back end of the trap.
6. Attach the trap to the pressurization manifold and, using a Gilibrator, measure the trap's resistance to flow. This is accomplished by carefully raising the pressure on the front of the trap and measuring the flow out the back until it reaches ~100 mL/min. If this pressure is greater than 1000 Torr the trap is packed too tightly and should be remade.

   When making 12" traps for the Autocan[12] connected to GCMS-A, note that these traps-although 6" longer-contain exactly the same aliquot of trap material as the 6" traps.

CHANGE HISTORY

1. Changes made in revision 9

This is a comprehensive update involving every SOP section. Some of the highlights are as follows.

1.1 This revision of the SOP combines TO-14A and TO-15 methods into one document.
1.2 Sample equipment listing updated and clarified.
1.3 Filename conventions and data handling have been updated.
1.4 Primary standards and holding times have been updated.
1.5 The current ways of handling sample dilutions has been added.
1.6 Added Appendix A, Tekmar trap repacking process.

2. Changes made in revision 10

Small update reflecting modest changes.

2.1 Changed expiration dates on calibration standards to two months, up from one month.
2.2 Updated the appendix discussion on packing new traps for the Tekmar units.
2.3 Updated Section 3.2 to reflect AFCEE 4.0 RL for SCAN level samples of 0.50ppbv, down from the 1.0ppbv previously listed.
2.4 Updated Tables in Section 9.2.5 to reduce number of cal standards run on each instrument.

3. Changes made in revision 11

Small update to comply with DOD criteria.

3.1 Changed front page to replace QA officer signature with technical lead signature.
3.2 Added reference in 7.0 to the purchasing SOP.
3.3 Added reference in 7.0 to metrology and equipment verification matrix.
3.4 Added the following to section 8.0: Any standard that is prepared in the laboratory shall be verified against current standards, or in the case of calibration standards against a second source calibration verification standard, prior to use. This verification shall be recorded in the standard logbook.
3.5 Changed section 8.0 that explains where standards are logged into. They are no longer logged into a notebook but into the chemical inventory database.
3.6 Added a discussion on manual integrations to section 12.
3.7 Added information about uncertainty and updated sources of error to section 9.
3.8 Added sentence to Table 2 about client specified RL.
3.9 Added a statement of what happens when a sample falls outside the calibrated range of the instrument.
3.10 Added a discussion to 9.6 regarding rerunning a blank versus reporting with qualifiers.
3.11 Added a discussion to 9.8 regarding rerunning the LCS versus reporting with qualifiers.
3.12 Removed the injection of 50 µL milli-pore water to blank can in section 9.6.
3.13 Added a caption to Figure 1.
3.14 Added reference to RPD controlled form.
3.15 Fixed section 7 numbering.
3.16 Added SOP30 to references.

4. **Changes made in revision 12**

Small update to address internal audit concerns and new internal standard.

4.1 Adjusted preparation, expiration, and values of internal standard throughout.
4.2 Added the use of 5.4L Summa canisters.
4.3 Removed use of written logbook for sample receipt and changed to internal COC in section 6.3.
4.4 Removed notification of client for early canister cleaning in section 6.8.
4.5 Changed the range of SIM standards in section 8.3.1.
4.6 Updated instrument and GC column ID's in section 7.5.
4.7 Removed daily leak check from section 10.
4.8 Updated current Tune methods in section 9.1.
4.9 Changed gas type for N2 and He from grade 5 to UHP in section 8.6.
4.10 Changed file locations to hyperlinks.
4.11 Updated formatting and layout in all tables.
4.12 Added references to equations throughout the text.

5. **Changes made in revision 13**

5.1 Removed all references to Method TO-12
5.2 Added Hyperlinks to all SOP, CHP, and QAP references.
5.3 Added new cover page
5.4 Updated SIM calibration scheme table to reflect new 8 level calibration scheme
5.5 Corrected BFB Tune table
5.6 Updated sections 8.2.1 and 8.2.1.1.2 to reflect internal standard expiration date of 7 years.
5.7 Removed references to AFCEE3.0
5.8 Updated SCAN RL's to 1.0ppvb
5.9 Changed MDL statement to reflect new MDL/SDL/LOD policies.
5.10 Updated the tune information for GC/MS-G from Stune to BFB tune.

Appendix C
Field Sampling Plan

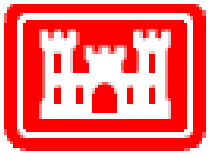
Final Field Sampling Plan

RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant Former Hanley Area St. Louis, Missouri

Contract No. W912DQ-11-D-3005 Task Order 0009

Prepared for



Department of the Army

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December 2013

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Contents

Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DFW	definable features of work
FD	field duplicate
FSP	field sampling plan
FTL	field team lead
ID	identification
IDW	investigation-derived waste
MS	matrix spike
MSD	matrix spike duplicate
OU	operable unit
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QCP	Quality Control Plan
RI	remedial investigation
RSC	Regional Support Command
SIM	selective ion mode
SOP	standard operating procedure
TBM	temporary benchmark
TeCA	tetrachloroethene
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VI	vapor intrusion
VOC	volatile organic compound

1. Project Background

This field sampling plan (FSP) was prepared for the U.S. Army Corps of Engineers (USACE)–Kansas City District under Contract No. W912DQ-11-D-3005. The FSP describes the field activities and procedures that will be performed as part of a remedial investigation (RI) for Operable Unit (OU) 2—Vapor Intrusion Pathway.

1.1 Site History and Contaminants

The Executive Summary and Worksheet #10 (Conceptual Site Model) of the Uniform Federal Policy–Quality Assurance Project Plan (UFP-QAPP) describes the site history and contaminants.

1.2 Site-specific Definition of Problems

Worksheet #11 (Project/Data Quality Objectives) of the UFP-QAPP presents the site-specific definition of problems and associated data quality objectives.

2. Project Organization and Responsibilities

Section 2 identifies the principal members of the project team and subcontractors for the RI activities. Table 2-1 specifies the team members and their contact information.

TABLE 2-1
Contact Information
Field Sampling Plan—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Name	Organization	Telephone/Fax	E-mail	Address
Jonathan Harrington Project Manager	U.S. Army Environmental Command	P 210-466-1719 C 210-793-7917	jonathan.harrington2.civ@mail.mil	U.S. Army Environmental Command SFIM-AEC-CD Building W2264 2450 Connell Road Fort Sam Houston, TX 78234-7664
Josephine Newton-Lund Project Manager	USACE–Kansas City District	P 816-389-3912 F 816-389-2008	josephine.M.Newton-Lund@usace.army.mil	USACE CENWK-PM-EP 601 East 12th Street Kansas City, MO 64106
Dave Moore Chief, Environmental Division	88th Regional Support Command (RSC)	P 608-388-0366 F 608-388-0607 C 612-713-3822	david.moore31@usar.army.mil	88th RSC 60 South O Street Ft. McCoy, WI 54656
Barry McFarland Environmental Protection Specialist	88th RSC (J.M. Waller)	P 316-681-1759 F 316-652-2324 C 316-616-8649	barry.l.mcfarland2.ctr@mail.mil	88th RSC 3130 George Washington Boulevard Wichita, KS 67210
Chris English Project Manager	CH2M HILL	P 314-335-3012 F 314-421-3927 C 314-749-1550	chris.english@ch2m.com	CH2M HILL 1034 South Brentwood Boulevard, Suite 2300 St. Louis, MO 63117
Tony Swierczek Assistant Project Manager	CH2M HILL	P 314-335-3043 F 314-421-3927 C 618-550-1244	aswiercz@ch2m.com	CH2M HILL 1034 South Brentwood Boulevard, Suite 2300 St. Louis, MO 63117
Loren Lund Toxicologist and CH2M HILL Vapor Intrusion (VI) and Human Health Risk Assessment Practice Leader	CH2M HILL	P 208-357-5351 C 208-821-1932	loren.lund@ch2m.com	CH2M HILL 787 East 1500 North Shelley, ID 83274
Glynn Roberts Field Team Leader and Site Safety Coordinator	CH2M HILL	P 314-335-3038 F 314-421-3927 C 314-324-4161	glynn.robertst@ch2m.com	CH2M HILL 1034 South Brentwood Boulevard, Suite 2300 St. Louis, MO 63117

TABLE 2-1
Contact Information
Field Sampling Plan—RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)
St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Name	Organization	Telephone/Fax	E-mail	Address
Mark Orman Health and Safety Manager	CH2M HILL	P 414-847-0597 C 414-712-4138	mark.orman@ch2m.com	CH2M HILL 1034 South Brentwood Boulevard, Suite 2300 St. Louis, MO 63117

2.1 U.S. Army Corps of Engineers

USACE - Kansas City District is responsible for overall project administration, including contracting and procurement, submittals management, cost and schedule management, and investigation oversight. Josephine Newton-Lund is the project manager responsible for overall project management. Ms. Newton-Lund will coordinate project matters with CH2M HILL and with other USACE team members and stakeholders, as appropriate.

2.2 Contractor

CH2M HILL has been selected as the environmental contractor responsible for implementation of the work, as defined in the Scope of Work (USACE 2012) and described herein. CH2M HILL will provide the necessary resources to execute the defined scope consistent with the Scope of Work.

Chris English will serve as the project manager and the USACE-certified construction quality management officer. The project manager is responsible for administering the project and ensuring that sufficient resources are available, including experienced and qualified personnel, and the overall implementation of this plan. As the construction quality management officer, he will be responsible for total project quality and administration of the UFP-QAPP.

Anthony Swierczek will serve as the assistant project manager and will assist the project manager, as needed. Other key CH2M HILL personnel include Dr. Loren Lund as the toxicologist and vapor intrusion (VI) and human health risk assessment subject matter expert, Doug Scott as the senior chemist, Shane Lowe as the project chemist, and Susanne Borchert as the independent technical review team leader. Other CH2M HILL personnel include Glynn Roberts who will serve as the field team leader (FTL) and site safety coordinator for field activities.

2.3 Subcontractors

CH2M HILL will procure subcontractors and suppliers. Subcontractors will be evaluated during the procurement process with respect to safety records, cost, experience, qualifications, and available resources. Anticipated subcontractor needs include the following:

- Drilling services
- Surveying services
- Investigation-derived waste (IDW) disposal services
- Offsite analytical services

3. Project Scope

An RI will be conducted at the site following the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) response process for contaminated sites. The investigation objectives of the RI are presented in the Executive Summary and the data quality objectives are presented in Worksheet #11 of the UFP-QAPP. The RI will be performed in general conformance with U.S. Environmental Protection Agency (USEPA) CERCLA guidance.

3.1 Task Description

The project team will conduct various field activities as part of the RI to determine if site-related volatile organic compounds (VOCs) in shallow groundwater north of the former Hanley Area could contribute to VI at offsite residences and evaluate if further action is warranted. The RI will include the following:

- Installing and developing colocated shallow and deep monitoring well pairs
- Surveying of newly constructed wells
- Groundwater sampling from existing and newly installed monitoring wells
- Installing subslab soil gas sample probes
- Collecting tunnel air, subslab soil gas, indoor air, and outdoor air samples
- Managing IDW

3.2 Applicable Regulations/Standards

3.2.1 Site Access

The former Hanley Area is owned by the 88th RSC. The site is adjacent to the north end of the Sverdrup U.S. Army Reserve Center located at 4301 Goodfellow Boulevard in St. Louis, Missouri. Goodfellow Boulevard runs along the eastern boundary of the site, and Stratford Avenue runs along the northern boundary. The site perimeter is surrounded by a chain-link fence and is accessible through a gate on the south side through the U.S. Army Reserve Center's property. Site access will be coordinated through a representative from the 88th RSC located within the U.S. Army Reserve Center. The north part of the former Hanley Area is also accessed through a gate and will also be coordinated as necessary through the same representative from the 88th RSC.

Residential properties are located north of the site, and a property occupied by Job Corps is located adjacent to the west boundary of the site. RI work requiring access to these properties will be coordinated by USACE with property owners prior to mobilization.

3.2.2 Work Hours

Site work will be conducted during daylight hours. Site work on or close to residences requiring the use of heavy machinery (drill rigs) will be completed during time periods agreed upon by property owners, to the extent that it does not affect the project schedule.

3.2.3 Demobilization

At the completion of project activities, sampling locations will be returned to near-original conditions whenever possible. Effort will be made to minimize impacts to work sites and sampling locations. Following the completion of work at a site location, drums, debris, and other waste will be removed. Decontamination areas will be dismantled immediately after completing the RI.

3.3 Project Schedule

The projected schedule for field activities is provided as Figure 15 in the UFP-QAPP.

4. Nonmeasurement Data Acquisition

The site physical characteristics including climate, topography, surface water hydrology, geology, and hydrogeology are described in Worksheet #10 of the UFP-QAPP.

5. Remedial Investigation Field Activities

Section 5 outlines the procedures to be followed during the RI fieldwork. Fieldwork will be performed in Level D personal protective equipment (PPE). If contamination or hazards are encountered that require increased health and safety precautions, required changes will be discussed with USACE. The manufactured material of the sampling devices (Teflon, polyvinyl chloride [PVC], and metal) discussed in the following subsections will be appropriately selected to minimize interference with the chemical analyses being performed.

5.1 Standard Operating Procedures

The following standard operating procedures (SOPs) are provided in Attachment A of this FSP and present specific instructions to complete the required field activities:

- Soil Boring Logging
- Monitoring Well Installation and Development
- Decontamination of Drill Rigs and Equipment
- Decontamination of Personnel and Equipment
- Low-flow Groundwater Sampling
- Water Sample Collection for VOCs
- Water Level Measurements
- Conducting Building Surveys for Vapor Intrusion Evaluations
- Collection of Subslab Gas Samples Using SUMMA Canisters
- Collection of Subslab Gas Samples Using SUMMA Canisters – Alternate Method
- Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters
- Organic Vapor Monitor

Laboratory SOPs are provided in Appendix B of the UFP-QAAP.

5.2 Utility Clearance

CH2M HILL will contact the Missouri one-call utility locate service (1-800-DIG-RITE) to request a dig ticket for utility locate activities within the investigation area. The request will be made at least 2, but not more than 10 working days prior to mobilization. If onsite utilities cannot be marked by the one-call service, the utilities will be verified through onsite utility maps. In the absence of onsite utility maps, soil boring locations will be pre-probed with a utility probe. A minimum clearance of 3 feet will be maintained at sample locations from underground utilities. Additionally, a minimum distance of 20 feet will be maintained from overhead power lines. Dig tickets will be renewed if RI work is not actively being conducted and the dig ticket is older than 10 working days or if work or weather has obliterated the original lines. A renewal is not required if RI work is actively being conducted onsite and the markings are still visible.

Onsite utilities and private utilities will be verified through onsite utility maps and through a private utility locate using radio frequency techniques and ground-penetrating radar. An attempt to locate utilities beneath the basement slabs will be performed at the residences, if given approval by the resident to do so. If utilities under the basement slab cannot be located using the methods described above (or not granted approval by the resident), the locations of the utilities will be estimated based on the locations of entry points, floor drains, and cleanouts.

5.3 Monitoring Well Soil Borings

Soil borings will be advanced using hollow-stem auger methods to facilitate installation of the colocated shallow and deep overburden monitoring wells. The locations of the proposed colocated monitoring wells are provided in Figure 10 of the UFP-QAPP. The USACE will submit the location to affected property owners, if appropriate. Locations will be marked and utilities cleared before intrusive activities begin. Further discussion of the RI groundwater investigation approach is presented in Worksheets #10, 11, 14 and 16 (combined), 17, and 18 of the UFP-QAPP.

5.3.1 Soil Boring Advancement

Soil borings to facilitate installation of the colocated shallow and deep overburden monitoring well pairs will be positioned as close to each other as possible (generally within 18 inches). The deep soil boring will be advanced to the top of the overburden and weathered shale contact, and the shallow colocated soil boring will be advanced to a depth that will allow the screened interval to straddle the water table. If feasible, the shallow soil boring will terminate above the sand filter pack of the deep colocated monitoring well so that the screened intervals of the colocated well pair do not overlap. Soil boring installation activities will conform to the Missouri Well Construction Rules (10 *Code of State Regulations* 23-1.010 through 6.060).

The drilling rig will be set up and operated in accordance with standard drilling practices and in a manner consistent with the safe and efficient operation of the equipment. To ensure a detailed description of subsurface conditions, soil samples from the deep colocated borings will be logged continuously using the Unified Soil Classification System in accordance with American Society for Testing and Materials (ASTM) D2488 (visual-manual method for field description). Soil samples will be continuously screened using a photoionization detector and inspected for discoloration, staining, and odors. The soil boring log will include observations relative to soil type, grain size distribution, changes in lithology, stained soil or chemical odor, soil moisture, depth to the water table, total depth of boring, and photoionization detector screening results. Soil borings will be advanced and logged in accordance with the SOPs for *Soil Boring Logging* and *Organic Vapor Monitoring* (Attachment A). The drill rig and sampling equipment will be cleaned and decontaminated in accordance with the SOPs, *Decontamination of Drill Rigs and Equipment* and *Decontamination of Personnel and Equipment*. (Attachment A). IDW will be handled as discussed in Section 8 of this FSP.

5.3.2 Soil Boring Abandonment

In the event of refusal before the anticipated soil boring termination depth or other encumbrances prevent the advancement of the soil boring, the soil boring will be abandoned in accordance with applicable State of Missouri requirements, and a second soil boring will be attempted. Locations may be adjusted in the field with USACE concurrence if soil borings cannot be advanced because of surface structures or aboveground/underground utilities. An approved non-slurry bentonite (chipped or pelletized and hydrated in place with potable water if in the unsaturated zone) will be placed from the bottom to the top of the hole using the hollow-stem auger to emplace the bentonite. Abandoned soil borings will be checked 24 hours after abandonment to ensure that no settlement occurred and that the materials cured properly. If settling has occurred, non-slurry bentonite will be added to fill the hole to near-ground surface. Like surface materials will be used to complete the upper 6 inches of the soil boring. The drill rig and sampling equipment will be decontaminated in accordance with the SOPs, *Decontamination of Drilling Rigs and Equipment* and *Decontamination of Personnel and Equipment* (Attachment A).

5.4 Monitoring Well Installation and Development

As discussed in the UFP-QAPP worksheets, colocated shallow and deep overburden monitoring well pairs will be installed and screened at the overburden and weathered shale contact (deep monitoring well) and within the unconsolidated overburden (shallow monitoring well). Figure 10 of the UFP-QAPP presents the locations of the proposed colocated well pairs and Figure 16 of the UFP-QAPP presents construction details for the colocated well pairs. Existing monitoring wells MW-107, MW-108, and MW-109 terminate at the overburden/weathered shale contact, and their well screens are fully submerged. Therefore, shallow

colocated wells will be installed next to each of the existing wells to assess groundwater conditions at the water table. The colocated well pairs will be installed and developed in accordance with the SOP, *Well Installation and Development* (Attachment A). IDW will be handled as discussed in Section 8.

Because of uncertainties associated with the depth to water northwest of the former Hanley Area, near PP-17, and near the day care center, the deep monitoring wells will be installed first in order to collect static water level measurements. The installation depth of the shallow wells will be based on water level measurements collected at the deep wells.

5.4.1 Deep Monitoring Well Installation

As discussed in Section 5.3, hollow-stem auger drilling techniques will be used to advance the soil borings to facilitate installation of the colocated well pairs. The deep monitoring wells will be constructed of 2-inch-diameter, factory-manufactured, flush-jointed, Schedule 40 PVC riser and screen (0.01-inch machine slot size). The well screen will be 10 feet long, and a PVC plug will be threaded onto the bottom of the well screen.

The annular space surrounding the well screen will be completed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded siliceous sand. The primary sand filter pack will extend from the bottom of the borehole to within 1 to 5 feet above the well screen. For the purpose of this RI, the sand filter pack will extend 2 feet above the well screen. The drilling subcontractor will use a weighted tape to monitor the depth of the sand pack during placement. The filter pack will be allowed to settle before a final measurement is taken of the top of sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. If the screen is set more than 25 feet into the saturated zone, the filter placement will be by tremie pipe, unless hollow-stem augers will be used.

A bentonite seal will be installed atop the sand filter pack. The bentonite seal will consist of a minimum 2 feet of bentonite chips or pellets. The bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. The top of the bentonite seal will be measured after it has been allowed to hydrate and before the annular seal is applied.

An annular seal will be placed atop the bentonite seal. The annular seal will be placed directly over the bentonite seal and will extend from the bentonite seal to the base of the surface completion. The type of grout used for the annular seal will consist of high solids sodium bentonite slurry, at least 20 to 30 percent weight by solids. The grout will be pumped into the annular space in one continual operation using a side-discharge tremie pipe.

The monitoring wells will be completed with flush-mount well protectors. The flush-mount well protector will consist of a watertight well vault equipped with a cast-iron lid and aluminum skirt. A 2-foot-square by 4-inch-thick concrete pad will be poured around the well vault. The concrete pad will be finished in such a manner that surface water drains away from the well vault. The monitoring well riser will be equipped with a watertight well cap (J-plug type) and lock keyed similar to other monitoring wells installed as part of the investigation. The CH2M HILL geologist or engineer providing oversight of each monitoring well installed will complete a flush-mount monitoring well completion form (Attachment A).

5.4.2 Shallow Monitoring Well Installation

As discussed in Section 5.3, hollow-stem auger drilling will be used to advance the soil borings. Based on historical groundwater levels observed at monitoring wells MW-107 through MW-109, Missouri well construction rules for shallow monitoring (defined in 10 *Code of State Regulations* 23-4.010 as a means for obtaining groundwater samples from a monitoring well within 5 feet of ground surface) will apply at these locations. Shallow monitoring well construction rules may also apply at the shallow wells northwest of the former Hanley Area, near PP-17, and near the day care center, based on water levels measured at the corresponding deep colocated wells or conditions observed during drilling the shallow well borehole.

The shallow monitoring wells will be constructed of 2-inch-diameter, factory-manufactured, flush-jointed, Schedule 40 PVC riser and screen (0.01-inch machine slot size). The well screen will be 10 feet long, and a PVC plug will be threaded onto the bottom of the well screen.

The annular space surrounding the well screen will be completed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded siliceous sand. The primary sand filter pack will extend from the bottom of the borehole to a minimum of 6 inches above the well screen. The drilling subcontractor will use a weighted tape to monitor the depth of the sand pack during placement. The filter pack will be allowed to settle before a final measurement is taken of the top of sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface.

In accordance with Missouri well construction rules, monitoring wells constructed for shallow monitoring must have a minimum combined annular seal and bentonite seal of at least 1 foot. To comply with this requirement, shallow monitoring wells will be installed such that the top of the well screen is at least 2 feet below the top of flush-mounted riser. The screened interval in each shallow well will be selected based on the water level observed in the corresponding deep well in the colocated well pair. A bentonite seal will be installed atop the sand filter pack. The bentonite seal will consist of bentonite chips or pellets. The bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. The top of the bentonite seal will be measured after it has been allowed to hydrate and before the annular seal is applied.

If sufficient room remains in the annulus around the well riser, an annular seal will be placed atop the bentonite seal. The annular seal will be placed directly over the bentonite seal and will extend from the bentonite seal to the base of the surface completion. The type of grout used for the annular seal will consist of high solids sodium bentonite slurry, at least 20 to 30 percent weight by solids. The grout will be pumped into the annular space in one continual operation using a side-discharge tremie pipe.

The monitoring wells will be completed with flush-mount well protectors. The flush-mount well protector will consist of a watertight well vault equipped with a cast-iron lid and aluminum skirt. A 2-foot-square by 4-inch-thick concrete pad will be poured around the well vault. The concrete pad will be finished in such a manner that surface water drains away from the well vault. The monitoring well riser will be equipped with a watertight well cap (J-plug type) and lock keyed similar to other monitoring wells installed as part of the investigation. The CH2M HILL geologist or engineer providing oversight of each monitoring well installed will complete a flush-mount monitoring well completion form (Attachment A).

5.4.3 Monitoring Well Development

Monitoring wells will be developed no sooner than 24 hours after installation. Each well will be developed by a combination of surging the well screen and pumping the monitoring well using an electric submersible pump. No air, detergents, soaps, acids, bleaches, or additives will be used during well development. A minimum of five well volumes will be removed during development plus the volume of water introduced during well installation. Well development will be continued until the required well volume is removed and the well water parameters have stabilized in accordance with the SOP, *Monitoring Well Installation and Development* (Attachment A). The monitoring wells also will be considered developed if the wells are purged dry. Groundwater parameters measured during well development will be recorded on well development forms (Attachment A). IDW will be handled as discussed in Section 8.

5.5 Monitoring Well Sampling

Groundwater samples will be collected from the existing and colocated well pairs using low-flow sampling methods. These methods include techniques appropriate for low-recovery systems. A low-recovery system is a system in which a stabilized water level cannot be obtained when pumping at a constant flow rate without drawdown regardless of pumping rate or equipment type. Worksheet #17 of the UFP-QAPP describes the field investigation activities planned and Worksheet #18 summarizes the sampling matrix, number of samples to be collected, analytical parameters, and the rationale for sampling location described in Worksheet #17.

Newly installed monitoring wells will not be sampled until water levels have reached equilibrium following well development.

5.5.1 Water Level Measurements

Water level measurements will be collected from the boreholes and monitoring wells in accordance with the SOP, *Water Level Measurements* (Attachment A) before groundwater sampling. Groundwater levels will be measured to the nearest 0.01 foot using an electronic water level indicator. Water levels will be measured in feet below top of casing. Measurements shall consistently be conducted from the same location on the PVC well casing that is either marked with a notch, or in the absence of a notch, on the north side of the casing.

5.5.2 Groundwater Sampling

Monitoring wells will be inspected for signs of tampering or other damage. Tampering, if suspected (for example, casing is damaged, lock or cap is missing), will be recorded in the field logbook and on the well sampling form and reported to the FTL. Monitoring wells that appear to have been tampered with will not be sampled until the FTL has notified the project manager to discuss the path forward with USACE.

Monitoring wells included in the VI assessments and groundwater investigation will be sampled during the same mobilization, when feasible. When numerous locations are to be sampled in succession, wells expected to have low levels of contamination or no contamination will be sampled before those expected to have higher levels of contamination. This practice will help reduce the potential for cross contamination between wells. Sampling activities will be recorded in the field logbook. Sampling data will be recorded on a groundwater sampling form (Attachment A).

Monitoring wells will be purged and samples collected for VOC analysis using the groundwater low-flow purging and sampling techniques presented in the SOPs, L*ow-Flow Groundwater Sampling* and *Water Sample Collection for VOCs* (Attachment A). The SOP includes techniques for low-recovery wells.

5.6 Vapor Intrusion Assessment

The objective of the VI assessment is to determine whether site-related contamination from the former Hanley Area has migrated under residences as soil vapor and whether it is potentially affecting indoor air quality at the residences by VI. The locations of the VI assessments are provided in Figure 3 of the UFP-QAPP. Further discussion of the VI assessment approach is presented in Worksheets #10, 11, 14, and 16 (combined), 17, and 18 of the UFP-QAPP.

5.6.1 Conduct Site Visit

Prior to collecting the first round of samples at a residence, CH2M HILL will conduct a site visit to the residence to collect information for the VI assessment. During the site visit, CH2M HILL will interview the residents and perform a limited building inspection to obtain the following information:

- Occupancy status (for example, number of people living at the residence, duration at the current residence, age of occupants, etc.)
- General building layout, including number of floors and approximate floor space area
- Building construction characteristics, including foundation type, basement or crawl space details, and heating and ventilation system information
- Types of chemical products used and stored inside the residence that may contain VOCs
- Still photographic documentation of basement conditions

CH2M HILL will record the information on a questionnaire/building survey form provided in Attachment A. The building survey will be conducted in accordance with the SOP, *Standard Operating Procedure for Conducting Building Surveys for Vapor Intrusion Evaluations*. During the initial site visit, CH2M HILL will notify residents of the proposed locations of the groundwater (PP-17 only), subslab soil gas, indoor air, and outdoor air samples and will obtain verbal approval from residents regarding the locations.

5.6.2 Subslab Soil Gas, Indoor Air, and Outdoor Air Sampling

Subslab soil gas, indoor air, and outdoor air samples will be collected during the VI assessments. At PP-17 (Figure 3 of the UFP-QAPP), groundwater sampling will also be conducted. To assess temporal variability in chemical concentrations, subslab soil gas, indoor air, and outdoor air samples will be collected during multiple events. If multiple events are conducted, to the extent possible, the same sample locations will be investigated during each event. Worksheet #17 of the UFP-QAPP describes the field investigation activities planned, and Worksheet #18 summarizes the sampling matrix, number of samples to be collected, analytical parameters, and the rationale for sampling location described in Worksheet #17.

Following USACE receipt of a signed right-of-entry form from the property owner, CH2M HILL will contact the residents to set a 3-day schedule for the VI assessment (for example, subslab soil gas, indoor air, and outdoor air sampling). A 4-day schedule will be set for residences where groundwater sampling will be conducted. CH2M HILL will contact Missouri One-Call to mark utilities on the property coming into the building from outside. A third-party utility locating company will conduct a private utility locate in the basements of the residences (when possible) and where monitoring well installation activities will be conducted. Refer to Section 5.2 for utility clearance procedures.

After confirming that utilities have been marked, CH2M HILL will conduct the VI assessment. Field activities will be performed by a two-person CH2M HILL team consisting of the FTL/quality control (QC) officer and a field team member who is experienced in groundwater sampling and subslab soil gas, indoor air, and outdoor air sampling.

5.6.2.1 Subslab Soil Gas Sampling

Following confirmation that utilities have been marked, CH2M HILL will mobilize to the selected residences north of the former Hanley Area to conduct the VI assessments. The subslab soil gas sampling probes will remain in the slab for possible subsequent sampling events. Subslab soil gas sample probes were previously installed at PP-2 and PP-3 (Figure 3 of the UFP-QAPP).

On the first day of the investigation, CH2M HILL will install up to 2 subslab soil gas probes through the floor of the basement at locations identified during the site visit (Section 5.6.1). Work will be conducted in accordance with the SOP, *Collection of Subslab Gas Samples Using SUMMA Canisters* provided in Attachment A. At each location, the concrete will be cored using a hammer drill. A $^{7}/_{8}$- or 1-inch-diameter hole will be drilled to a depth of 1 ¾ inches for installing the probe nut and probe union. Cuttings will be removed with a portable vacuum cleaner.

A $^{5}/_{16}$- or ½-inch-diameter hole will be drilled through the remainder of the slab and approximately 3 inches into the subslab material. Depending on the slab thickness, it may not be possible to install the entire length of the probe nut and probe union within the slab. The ¼-inch-diameter stainless steel probe installed on the probe nut may extend beyond the bottom of the slab. If this occurs, the ¼-inch-diameter stainless steel probe will be cut to a sufficient length and Teflon tape wrapped around it to prevent mortar fouling of the probe. If the probe extends into the bedding material, the $^{5}/_{16}$- or ½-inch-diameter hole will be drilled approximately 3 inches beyond the installation depth of the probe to allow for a void that is free of obstructions that might plug the probe during sampling. The SOP, *Collection of Subslab Gas Samples Using SUMMA Canisters—Alternate Method* (Attachment A), provides procedures for installing the subslab soil gas probes through slabs less than the required thickness.

Cuttings will be removed with a portable vacuum cleaner. The probe and probe union will be mortared into the hole to provide an airtight seal around them. The probe union will be installed flush with the floor surface, and the mortar will be allowed to dry for approximately 24 hours.

On the second day of the VI assessment, CH2M HILL will deploy sample canisters for subslab soil gas, indoor air, and outdoor air sampling. Fieldwork will be sequenced this way to avoid possible interference between the installation of the subslab probe (completed on the previous day) and the indoor air sampling. For each subslab soil gas probe, CH2M HILL will conduct a leak check before sampling. The leak check will use helium gas as a tracer to determine whether indoor air is infiltrating into the subslab sample probe during purging.

A minimum of 2 liters of subslab soil gas will be purged into Tedlar bags during the leak check prior to sampling. Leak check procedures are described further in the SOP provided in Attachment A.

Six-liter, individually certified SUMMA canisters will be used to collect the subslab soil gas samples. The canisters will be kept open for 24 hours using a flow controller set for 3.75 milliliters per minute, which will allow the SUMMA canister to fill over a 24-hour period.

For quality assurance (QA) purposes, field duplicates will be collected from subslab soil gas sample locations.

If subslab soil gas samples cannot be collected due to low air permeability associated with tight soils or saturated conditions beneath the slab, the condition will be noted in the field sampling log provided in the SOP (Attachment A).

5.6.2.2 Indoor Air and Outdoor Air Sampling

On the second day of the investigation, CH2M HILL will place and open a 6-liter, individually certified SUMMA canister in the basement of the residence to collect an indoor air sample. A 6-liter SUMMA canister will be placed and opened outside the residence to collect an outdoor air sample. The canisters will be kept open for 24 hours using a flow controller set for 3.75 milliliters per minute, which will allow the SUMMA canister to fill over a 24-hour period.

Additional information regarding indoor air and outdoor air sampling is provided in the SOP, *Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters*, in Attachment A.

For QA purposes, field duplicates will be collected from indoor air sample locations.

5.6.2.3 Subslab Soil Gas, Indoor Air, and Outdoor Air Canister Retrieval

On the third day of the investigation, CH2M HILL will return to the residence and close the sample ports on the subslab soil gas, indoor air, and outdoor air SUMMA canisters. CH2M HILL will arrive at the residence before 24 hours have elapsed since the canisters were opened to ensure the canisters have not reached atmospheric pressure prior to closing the valves. The canisters will be shipped to the offsite laboratory.

5.7 Laboratory Analyses

Groundwater samples will be shipped to Spectrum Analytical, Inc., in Tampa, Florida. Spectrum Analytical is the laboratory that analyzed groundwater samples during previous investigations and subsequent long-term monitoring groundwater sampling events under OU-1 of the former Hanley Area. Samples will be analyzed for VOCs by USEPA Method 8260B. Samples will be analyzed on a standard 21-calendar-day turnaround time.

Subslab soil gas, indoor air, and outdoor air samples will be shipped to CH2M HILL's Applied Science Laboratory in Corvallis, Oregon, which analyzed samples during previous investigations and subsequent vapor intrusion assessments under OU-1 of the former Hanley Area. Applied Science Laboratory is certified by the National Environmental Laboratory Accreditation Conference and is compliant with the Department of Defense *Quality Systems Manual*. Subslab soil gas, indoor air, and outdoor air samples will be analyzed for VOCs by USEPA Method TO-15 selective ion mode (SIM). Samples will be analyzed on a 15-calendar-day turnaround time.

The following chemicals will be reported by each laboratory:

- Benzene
- Carbon tetrachloride
- Chloroform
- 1,2-dichloroethane
- cis-1,2-dichlrorethene
- trans-1,2-dichlrorethene
- Methylene chloride
- Naphthalene
- 1,1,1,2-tetrachloroethene (TeCA)
- 1,1,2,2-TeCA
- 1,1,2-trichloroethane
- Tetrachloroethene
- Trichloroethene
- Vinyl chloride

The chemicals listed above are proposed because they exceeded screening levels in groundwater during previous investigations associated with the former Hanley Area.

One additional chemical, 1,1,1,2-TeCA, exceeded the screening level in groundwater and will be analyzed in the groundwater samples. However, it will not be included in the analyte list for subslab soil gas, indoor air, and outdoor air samples because it is not reported in the analyte list for Method TO-15 or the Compendium Method TO-15 (USEPA 1999), which adds compounds to the original Method TO-15. The omission of 1,1,1,2-TeCA in the reporting list is not considered a data gap because the chemical has not been detected in any offsite groundwater samples. The detectable presence of 1,1,1,2-TeCA is limited to one monitoring well, MW-111, located within the site boundaries of the former Hanley Area (Figure 2 of the UFP-QAPP).

If elevated subslab soil gas, indoor air, or outdoor air concentrations are observed using the TO-15 SIM method such that significant sample dilutions are required to bring reported concentrations within instrument calibration standards, then consideration will be made for using TO-15 SCAN for future subslab soil gas, indoor air, and outdoor air sampling events to reduce the required dilution of subsequent samples.

Screening levels, reporting limits, and QC limits for the USEPA Method 8260B and TO-15 SIM method are provided in Worksheet #15 of the UFP-QAPP.

5.8 Decontamination Procedures

The equipment used for field sampling will be decontaminated before and during sampling activities. This includes parts of the drill rig that come in contact with the formation soil, augers, pumps, soil and water sampling equipment, and water level measuring devices. Large pieces of equipment and tooling including drill rigs and hollow-stem auger tooling will be decontaminated within a decontamination pad constructed at an area designated by the field team. To minimize the handling of IDW containers, the decontamination pad will be located adjacent to the drum staging area. Smaller pieces of equipment, including direct-push technology core barrels, hand augers, and undedicated sampling equipment will be decontaminated in designated wash and rinse containers located adjacent to the sample location. At the end of each day, the decontamination fluids will be transferred to the drum staging area.

5.8.1 Drilling Equipment

Equipment decontamination activities will be conducted in accordance with the SOP, *Decontamination of Drilling Rigs and Equipment* (Attachment A), before drilling begins. Drilling/probing equipment and tooling will be decontaminated (as appropriate) before work begins, between sample intervals, between soil boring locations, before leaving the site at the end of each day, and at the conclusion of the drilling program. Decontamination of hollow-stem auger equipment and tooling will consist of washing the equipment with a high-pressure steam or hot water wash. Direct-push tooling will be decontaminated between sample intervals by hand scrubbing the equipment in wash and rinse solutions. Decontamination fluids will be handled in accordance with Section 8.

5.8.2 Sampling Equipment

Equipment decontamination activities will be conducted before sampling in accordance with the SOP, *Decontamination of Field Personnel and Equipment* (Attachment A). Sampling equipment will be decontaminated in the field before sampling and also between sampling locations. To the extent possible, disposable sampling equipment will be used. The following decontamination steps will be taken for reusable equipment:

- Liquinox detergent wash
- Distilled water rinse
- Air drying

If the equipment is not to be used soon, it must be stowed in such a manner to minimize potential cross contamination. Decontamination fluids will be handled in accordance with Section 8.

5.9 Sample Containers and Preservation Techniques

Sample containers, preservation methods, and volumes are specified in combined Worksheet #19 and 30 of the UFP-QAPP.

5.10 Field Quality Control Sampling Procedures

Section 5.10 summarizes the field QC samples to be collected from the site. The number of field QC samples for each sampling matrix and analytical method is provided in Worksheet #18 (Table 18-1) of the UFP-QAPP.

5.10.1 Field Duplicate

A field duplicate is an additional sample collected at the same time from the same location as the normal sample. They are intended to represent the same population and are taken through all steps of the analytical procedure in an identical manner. The samples are used to assess precision of the entire data collection activity, including sampling, analysis, and site heterogeneity.

Duplicate samples are collected simultaneously or in immediate succession, using identical recovery techniques, and are treated in an identical manner during storage, transportation, and analysis. The samples may be either colocated samples or subsamples of a single sample collection. Examples of colocated samples include side-by-side soil samples, while subsamples may be taken from one soil location. The sample containers are assigned a unique identification number in the field. Specific locations should be designated for collection of field duplicate samples before the beginning of sample collection. The standard collection frequency for duplicate samples is one for every 10 field samples.

5.10.2 Matrix Spike/Matrix Spike Duplicate

A matrix spike (MS)/matrix spike duplicate (MSD) is an aliquot of sample spiked with a known mass and concentration of specific analytes. The spiking occurs before sample preparation and analysis at the laboratory. To allow the analytical laboratory to run MS/MSD analyses, additional sample will be collected in the field (except for internal standards samples that contain enough volume for the MS/MSD analyses) to provide sufficient sample volume. One MS and one MSD sample will be collected at a rate of every 20 samples collected per matrix, excluding subslab soil gas, indoor air, and outdoor air samples. MS/MSDs are not applicable to these samples.

5.10.3 Equipment Blanks

An equipment blank is a sample of ASTM Type II reagent-grade water or deionized water poured into, over, or pumped through the sampling device, collected in a sample container, and transported to the laboratory for analysis. They also may be called rinse blanks or rinsate blanks. Equipment blanks are used to assess the effectiveness of equipment decontamination procedures.

Equipment blanks will be collected immediately after the equipment has been decontaminated. At a minimum, equipment blanks will be collected at a frequency of one per 20 samples or one per week (whichever is more frequent) per sampling crew for each decontaminated equipment type. The equipment blank samples will be analyzed for all laboratory analyses requested for the environmental samples collected at the site, excluding subslab soil gas, indoor air, and outdoor air samples.

SUMMA canisters and flow controllers used for subslab soil gas, indoor air, and outdoor air collection will be precleaned individually and certified by the laboratory not to contain any target analyte greater than the detection limit.

5.10.4 Trip Blanks

Trip blanks are used to assess the potential introduction of contaminants to sample containers during the field collection event, including transportation and storage procedures. The trip blank consists of a volatile organic analysis sample vial filled in the laboratory with ASTM Type II reagent-grade water, transported to the sampling site, handled like an environmental sample (without being opened), and returned to the laboratory for analysis. Trip blanks will be used only when water samples for VOCs are taken. One trip blank will accompany each cooler of groundwater samples sent to the laboratory for analysis of VOCs.

5.10.5 Ambient (Field) Blanks

Ambient blanks are samples of ASTM Type II reagent-grade water or deionized water used in mimicking water sample collection procedures that involve exposing the sample to ambient air. The ambient blanks are designed to capture airborne contaminants that may get entrained in the sample while transferring the sample to the container. The blank will be analyzed for the analyses deemed to be potentially impacted by site conditions. One ambient blank will be collected during the groundwater investigation.

6. Field Operations Documentation

Section 6 provides general guidelines for the following: field documentation; sample containers; sample labeling, handling, and custody; and packaging and shipping.

6.1 Field Logbook

Field sampling activities will be recorded in field logbooks during the RI. The field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to the field crew, but stored in a secure location when not in use. The title page will contain the name of the person to whom the logbook is assigned; address for the logbook to be returned if found, logbook number, project number, project start date, and project end date. Entries will be recorded in indelible, waterproof ink. If an error is made in the field logbook, field form, chain-of-custody record, or other field document, a correction will be made by crossing a single line through the error, entering the correct information, initialing, and dating the information.

At the beginning of each day, the date, weather, personnel/contractors onsite, daily objective, and start time will be recorded. The date will be written at the top of every page of the logbook. The time of entry recordings will be in columnar form down the left-hand side of the page. If an entry is made in a nondedicated logbook, then the date, project name, and project number will be entered left to right, respectively, along the top of the right page. Entries will be dated and time of entry recorded. At the end of each day's entry or particular event, if appropriate, personnel will draw a diagonal line originating from the bottom left corner of the page to the conclusion of the entry and sign along the line, indicating the conclusion of the entry or the day's activity.

Entries in the field logbook must be legible and contain accurate and inclusive documentation of project activities, such as drilling, sample collection, and field measurements. Information pertaining to health and safety aspects, personnel onsite, visitors' names, association, and time of arrival/departure also will be logged. Language in the field logbooks must be objective and factual. Once completed, field logbooks will become accountable documents and must be maintained as part of the project files. The field logbooks will be audited from time to time to ensure compliance with this procedure.

Aspects of sample collection and handling, as well as visual observations, will be documented in the field logbooks. Sample collection equipment and field measurement equipment will be identified in the field logbooks. Calculations, results, and calibration data for field sampling and measurement of field parameters also will be recorded in the logbooks, except where the data are referenced as being recorded on approved field forms (Attachment A and Attachment B). Field measurements must be traceable to the specific piece of field equipment and to the field investigator making the measurement.

6.2 Photographic Records

When photographs or videos are taken for visual documentation of a site or procedure, they will be numbered to correspond to the field logbook entries. If possible, a reference point (such as a building or sign) will be included to assist in verifying the location of the photograph and providing an approximate scale. The name of the photographer, date, time, site location, and site description will be documented in the field logbook as photographs are taken. Photography will be coordinated with the USACE point of contact and residents (when applicable) to adhere to the security regulations and to maintain privacy of the resident.

6.3 Sample Documentation

6.3.1 Sample Identification Groundwater Samples

During the RI field activities, a consistent sample identification (ID) system will be employed to ensure uniqueness and clarity in sample names. This section describes the protocol that will be followed in naming samples that are submitted to the analytical laboratory and Worksheet #18 of the UFP-QAPP presents the sample IDs associated with the proposed sample locations depicted in Figures 3 and 10. Each sample collected will be assigned an ID number that includes the following information:

- Sample location type
- Sample location number
- Sample date

The analytical laboratory allows up to 12 characters in a sample name. The procedures described in this section must be followed closely to prevent sample tracking problems.

Sample Location Type

Sample IDs will begin with the two-letter designation for the sample location. The following abbreviation will be used: MW (monitoring well).

Sample Location

Sample locations will be designated by a 2- or 3-digit number. The monitoring wells will be assigned a number corresponding with the numbering sequence of existing monitoring wells.

Sample Date

The date that the sample was collected will be included in the sample ID.

Sample Numbering System

A complete sample name for sampling will consist of the four components listed below, using the following format: (sample location type)-(sample location)-(sample date)). For example, “MW-107-041213” represents the groundwater sample collected from monitoring well MW-107 on April 12, 2013.

6.3.2 Quality Assurance/Quality Control Sample Identification

QA/QC samples to be collected are specified in Sections 5.10, 5.11, and in Worksheet #18 of the UFP-QAPP. This subsection describes how ID numbers are to be assigned to QA/QC samples during field activities.

Equipment and trip blanks will be named according to the following examples:

- EB-01-041213: equipment blank sample number 1 collected on April 12, 2013
- TB-01-041213: trip blank set number 1 submitted with VOC samples packaged on April 12, 2013

MS/MSD samples will be named identically to ordinary environmental samples, except that the symbols “MS” and “MSD” will be added to the end of the sample name as appropriate. For example:

- MW-107-041213-MS (matrix spike)
- MW-107-041213-MSD (matrix spike duplicate)

Field duplicates will be named in a manner not readily discernible to the laboratory. Field duplicates will be identified using the following format: FD-(sample nimber)-(sample date).

For example, “FD-01-041213” indicates the first groundwater sample field duplicate collected on April 12, 2013. “FD-02-041213” indicates the second groundwater sample field duplicate collected on April 12, 2013.

6.3.3 Sample Label Identification

A sample label will be affixed to each sample container. Sample labels identify the sample with a unique ID number, the sample type, analytical method requested, sampler’s name or initials, date collected, time collected, and the preservation method used. The labels will be completed in waterproof, black ink. Labels that have preprinted sample IDs may be used. The remaining information is completed at the time of sample collection. Additional tape to secure sample labels is not to be used because of the potential for sample contamination from volatile chemicals in the adhesives. Samples will be placed in plastic bags for storage and shipment to prevent sample loss or damage caused by melting ice or by broken or leaking sample containers.

6.3.4 Sample Identification for Subslab Soil Gas, Indoor Air, and Outdoor Air Samples

A sample numbering system will be used to uniquely identify each sample, including field duplicates. Each analytical sample will be assigned a number as follows:

- Sample ID number – private property number (example "PP02")
- Sample matrix – XX ("SG" for subslab soil gas, "IA" for indoor air, and "AA" for outdoor air)
- Sample number
- Sample date – XXXXXX (example "041213")
- QC samples will receive FD (field duplicate) designation at the end of the sample ID

An example of the sample ID for a subslab soil gas sample collected at PP-02 on April 12, 2013 would be "PP02-SG-01-041213." A field duplicate at this location would have the sample ID "PP02-SG-01-041213-FD."

In addition to the sample ID, the label and chain-of-custody form will also contain the following information, as applicable:

- Date and time of sample collection – MM/DD/YY - HHMM
- Sample matrix or matrix identifier – Air
- Type of analyses to be conducted – TO-15 SIM (select VOCs; refer to Section 5.7)

The label, affixed to samples sent to the laboratory for analysis, and the chain-of-custody form will be written in indelible ink. The chain-of-custody form can be prepared electronically, when applicable.

6.3.5 Chain-of-Custody Field Procedures

Collecting data of known quality begins at the point of sample collection. Legally defensible data are generated by adhering to proven evidentiary procedures. The procedures must be followed to preserve and ensure the integrity of samples from the time of collection through analysis. Sample custody records must be maintained both in the field and in the subcontracted laboratory. Laboratory chain-of-custody procedures are discussed in combined Worksheet #26 and 27 of the UFP-QAPP. A sample is considered to be in someone's custody if it is either in his or her physical possession or view, locked up, or kept in a secured and restricted area. Until shipment, sample custody will be the responsibility of the FTL.

Chain-of-custody forms document sample collection and shipment to the laboratory. A chain-of-custody form will be completed for each sampling event. The original form will be provided to the laboratory with the sample shipping cooler, and a copy will be retained in the field documentation files. The chain-of-custody form will identify the contents of each shipment and maintain the custodial integrity of the samples. Responsible sampling team personnel will sign and date the chain-of-custody forms, sign the "relinquished by" box, and note the date, time, and air bill number noted on the chain-of-custody form. The laboratory will return the executed copy of the chain-of-custody with the hard copy report.

The shipping coolers containing the samples will be sealed with a custody seal when the coolers are not in an individual's possession or view before shipping. Custody seals will be signed and dated by the responsible sampling team personnel.

At a minimum, the chain-of-custody form must contain the following:

- Site name
- Task manager and project chemist names, telephone numbers, and fax numbers
- Unique sample ID
- Date and time of sample collection
- Source of sample (including name, location, sample type, and matrix)
- Number of containers
- Designation of MS/MSD
- Preservative used

- Analyses required
- Name of sampler
- Bill of lading or transporter tracking number (if applicable)
- Turnaround time
- Laboratory name, address, and contact information
- Special instructions
- Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratories

Erroneous entries on chain-of-custody records will be corrected by drawing a single line through the error and entering the corrected information. The person performing the correction will date and initial each change made on the chain-of-custody form.

6.3.6 Sample Packing and Shipping Requirements

In order to meet sample hold times, samples collected in the field will be transported to the laboratory as quickly as possible. The samples will be packed in insulated coolers with double-bagged ice sealed (to prevent leakage of water) to maintain the sample core temperature of 4±2 degrees Celsius, excluding the subslab soil gas, indoor air, and outdoor air samples. Samples will not be frozen. Accordingly, a temperature blank (a sample vial filled with tap water) will be included in every cooler and used to determine the internal temperature in the cooler upon its receipt at the laboratory.

SUMMA canisters will be packed in a rigid wall shipping container such as a cooler or heavy-duty cardboard box. SUMMA canisters will not be packed with other objects or materials that could cause them to puncture. Ice is not required for preservation of the subslab soil gas, indoor air, and outdoor air samples.

Packing material will be used to protect the sample containers from breakage during shipment. The completed chain-of-custody form will be sealed within a plastic bag and taped to the inside of the cooler lid. Each shipping container will be sealed with tape in two locations to secure the cooler, and chain-of-custody seals will be signed and dated and placed on either side of the lid to allow the receiver to identify tampering during transport to the laboratory. The shipping containers will be sealed with strapping tape for extra security during shipping.

The FTL or the project chemist will notify the laboratory of the field sampling activities and the subsequent transfer of samples to the laboratory. This notification will include information concerning the number and type of samples to be shipped and the expected date of arrival. Samples will be transported from the site to the laboratory by express shipment to ensure analysis within specified holding times. Samples will be shipped within 1 day of collection to ensure analysis within holding times. Samples requiring shipment by common carrier will be labeled and placed in accordance with applicable International Air Transportation Association regulations.

The laboratory custodian will verify that the custody seals on the sample shipment or the containers are intact and that the information on the chain-of-custody form matches the actual contents. The vacuum of each SUMMA canister will be checked upon receipt by the laboratory to ensure that vacuum was not lost in transport. The laboratory custodian also will note anomalies.

7. Surveying

Survey work for the project will consist of surveying the locations of various sampling activities across the site. The following are minimum standards for the work.

The surveyor will provide horizontal and vertical control for the site. Accuracy of the control shall be Third Order Class I as outlined in the Federal Geographic Data Committee's *Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Constructions (A/E/C) and Facility Management.*

The surveyor will provide coordinates of the points *x*, *y*, and *z* to the nearest 0.01 foot. Coordinates will conform to North American Datum of 1983 (Latest Adjustment) and North American Vertical Datum of 1988 with ties to the Missouri State Plane Coordinate System, Missouri East Zone FIPSZONE 2401, ADSZONE 4401, UTM Zones 15 and 16. Daily information will be recorded in field logbook format, and the data collector information will be provided to CH2M HILL. Level and horizontal traverse networks will be closed to the starting point and the errors recorded. If errors exceed the standards outlined below, the survey will rerun the horizontal and vertical traverses until the errors are eliminated within the acceptable range. Field notes will include the date, names of the crew, weather conditions, barometric pressure, and collected survey data information. Benchmarks will be turned through and become part of the level loop.

The accuracy standards include the following:

- Spot elevations will be measured to within ± 0.01 foot on hard surfaces (asphalt, concrete, utilities, etc.) and ±0.10 foot on other surfaces.
- Other physical features will be measured to within ± 0.2 foot of their true horizontal location.

Topographic and cultural features shall be tied so as to enable the calculation of coordinates of each feature shown on the site map. The type of feature tied will be identified in the field notes (for example, face of building, foundation, drip line).

7.1 Surveying of Monitoring Wells

The newly installed monitoring well locations will be surveyed for x, y and z coordinates. The x and y coordinates will be surveyed to the center of protective casing; the z coordinate (elevation) will be surveyed to the top of the riser pipe (with protective cap removed), and the ground elevation will be surveyed adjacent to the monitoring well completion concrete pad.

A minimum of two horizontal control points and two temporary benchmarks (TBMs) will be established within the work area. The control points and TBMs will be tied to existing reference control points previously identified by the surveyor. The control points and TBMs will be described in survey notes (provided by the subcontracted personnel), identified in the field, and protected.

The accuracy standards for surveying monitoring wells include the following:

- The elevation point for the monitoring wells will be established (and reported to the nearest 0.01 foot) at the top of the inner (plastic) well casing with the well plastic cap removed. A permanent mark (notch or ink) designating the elevation point will be established on the plastic monitoring well casing, typically the north side. This reading will require that the cover of the protective steel casing be unlocked and removed.
- Determine the elevation of the directly adjacent ground surface of each groundwater grab sample location and the monitoring wells (not the concrete pad surrounding the well casing). This will also be read to the nearest 0.1 foot.
- Determine the horizontal location coordinate of the monitoring well locations, or other station, from existing survey control monuments or other permanent land monuments (of known and higher accuracy) as near as possible to the immediate site area.

8. Investigation-derived Wastes

The field program will generate solid and liquid IDW requiring handling and disposal. IDW consists of materials that could pose a risk to human health and the environment (for example, sampling and decontamination wastes) as well as materials that have little potential to pose risk to human health and the environment (such as sanitary solid wastes). The following two types of IDW will be generated during field activities: indigenous and non-indigenous. Indigenous waste includes soil and aqueous material from sampling efforts. Non-indigenous waste is expected to consist of decontamination fluids and miscellaneous trash.

Waste management practices will be completed in compliance with current federal, state, and local regulations and in accordance with standard industry practices. IDW will be properly containerized in 55-gallon steel drums approved by the U.S. Department of Transportation. The drums will be staged at a designated sitewide drum staging area. The drum staging area will be determined during an initial reconnaissance visit prior to subcontractor mobilization. Subcontractors will transport drums from the point of generation to the drum staging area following completion of the subcontractor's activities. IDW will be characterized to determine the appropriate means of transport and disposal. Nonhazardous waste will be profiled, manifested, transported, and disposed of at an appropriate disposal facility. Purge water generated during groundwater sampling and decontamination activities will be placed in a 55-gallon drum may be disposed of in the City of St. Louis combined stormwater and sanitary sewer collection system upon approval from the Metropolitan Sewer District, pending characterization.

Material considered to be hazardous will be segregated from nonhazardous waste, profiled, manifested, and transported offsite as hazardous waste to a permitted hazardous waste facility, following USACE review and approval, and signature of the necessary paperwork by a U.S. Department of Defense representative.

Decontamination of sampling equipment may generate a small quantity of liquid that contains laboratory detergent. The quantities of detergent generated will be small relative to the volume of water used in decontamination, and the volume of water generated also will be small. Thus, the materials should be present at very low concentrations and in small quantities.

Disposable PPE will be decontaminated (if gross contamination is noted) with water, double-bagged, and disposed of in an onsite dumpster, if available. On the basis of the nature of the sampling activities, it is assumed that used PPE will not be considered a hazardous waste, even before decontamination. If PPE or disposable sampling equipment is determined to be potentially hazardous waste, it will be segregated and placed in a 55-gallon drum for characterization and disposal.

The field team will ensure that the containers are labeled, handled, stored, and secured in accordance with applicable state and federal regulations. Waste storage containers will be labeled immediately after waste has been first placed in the container. The following procedure will be used for waste container labeling:

- A weather-resistant label (for example, "Pending Analysis" label if the IDW has not been characterized at the time of generation) will be affixed and located on the upper one-third of each storage container. Alternatively, label information may be recorded directly on a clean, dry surface with an indelible white or silver paint marker.
- Each label will be placed on a smooth part of the container and will not be affixed across drum bungs, seams, ridges, or dents.
- Information to be recorded on each label includes the following:
  - Container number
  - Contents
  - Source of waste
  - Source location
  - Project name and site identification

  - Physical characteristic of the waste
  - Generation date

- Information documented on container labels will be recorded in the field logbook.
- Container labels will be protected in a manner to prevent damage or degradation of the recorded information.

Waste containers will be staged in a manner to accommodate inspection and sampling, if necessary, and to facilitate safe handling of the containers. Hazardous wastes, as defined under the Resource Conservation and Recovery Act, will be managed in accordance with the appropriate requirements. IDW will be removed from the site as soon as possible after receipt of the analytical results, but no longer than 90 days from generation.

9. Field Quality Assessment

QC will be maintained throughout fieldwork by means of a three-phase process. The three contractor QC phases, which include preparatory, initial, and follow-up, will be performed onsite by the QC officer, whom will hold a USACE Construction Quality Management certification. The role of the QC officer will be to summarize the activities of each contractor QC phase in the daily QC report. Contractor QC phases will be performed for each task that has separate control requirements. This section includes the following:

- Identification of contractor quality control representative
- Field equipment list
- Description of activities during the phases
- Identification of the definable features of work
- Sample table to match primary and QA samples, and other field control samples required

9.1 Contractor Quality Control

QC standards and procedures will be implemented to assure that the required levels of quality are consistently achieved during remedy implementation, including work performed by subcontractors and vendors. QC will be administered in accordance with the quality control plan (QCP) for the project (CH2M HILL 2012). Details of the QC program are provided in the following subsections.

9.1.1 Definable Features of Work

The QC system will be implemented by using a three-phase process for project definable features of work (DFWs) related to this RI. A DFW is a task that is separate and distinct from all other tasks and has a specific set of QC requirements (for example, monitoring well installation and sampling). DFWs are controlled during execution using the three phases of control discussed in the following sections and will undergo a completion inspection upon conclusion of the work associated with the DFW. The QCP tracks the status of QC activities related to the DFWs. The quality and performance requirements for each DFW are defined in the UFP-QAPP. SOPs are also included in this FSP and UFP-QAPP as required to support QC of the DFWs. A DFW tracking log and summary table is included in Appendix B of the QCP.

9.1.2 Three-phase Quality Control Process

Each phase of the control process presents the programmatic requirements for ensuring that the DFW is completed in a coordinated and efficient manner, with the highest level of integrity and quality, that is, “zero defects.”

The QC officer is responsible for the execution of the preparatory, initial, and follow-up control activities; testing required demonstrating the adequacy of the DFW; inspections related to the DFWs; identification and correction of any noncompliance with contract requirements for the DFW; and documentation of all QC activities related to the DFW. Additional qualified QC staff may be used to assist the QC officer in the various QC activities to accommodate variations in workload and/or specific areas of technical expertise; however, the QC officer is ultimately responsible for ensuring the QC of the DFWs.

9.1.2.1 Preparatory Phase

The preparatory phase is executed prior to initiating a DFW. The QC officer will conduct a preparatory-phase meeting to ensure that all necessary pre-construction activities have been completed, including the following:

- Permit requirements and approvals
- Notifications
- Submittal(s) approval
- Materials management
- Specifications and drawings review

The preparatory phase also establishes equipment and manpower requirements and defines personnel roles and responsibilities. Safety and health requirements are also identified and discussed during the preparatory phase of QC. The preparatory phase meeting will be scheduled by the QC officer, and notification will be given to USACE a minimum of 24 hours prior to the planned meeting. Other meeting attendees include the health and safety manager, project manager, FTL/site safety coordinator, subcontractors, and project stakeholders. Minutes from the preparatory meeting will be prepared by the QC officer and distributed to meeting attendees within 24 hours of the meeting. Section 5 of the QCP presents more information regarding implementation of the preparatory phase process.

9.1.2.2 Initial Phase

The initial phase of the QC process ensures that the requirements and methods identified during the preparatory phase are implemented appropriately. The initial phase establishes the minimum quality requirements, workmanship, and methods for execution of the DFW or task. It is implemented during the DFW inception, prior to significant work completion.

An initial phase inspection will be scheduled by the QC officer, and notification will be given to USACE 24 hours prior to the planned inspection. The inspection will establish the protocol for the associated DFW and ensure that work is completed in accordance with the preparatory phase QC and health and safety requirements. An initial phase inspection report will be prepared by the QC officer and distributed to USACE within 24 hours of the inspection. Noted deficiencies will be managed in accordance with Section 6.5 of the QCP. Section 5 of the QCP presents more information regarding implementation of the initial phase inspections.

9.1.2.3 Follow-up Phase

The follow-up phase of the QC process is completed during DFW execution to ensure that the minimum quality requirements established during the initial phase are being met. The follow-up phase covers work completed from the end of the initial phase through the completion of the DFW, as well as required testing and inspections.

The USACE representative will be notified 24 hours in advance of any scheduled inspection or test. Materials, installation, or fabricated components may be rejected for nonconformance at any stage of the three-phase quality control process. If a nonconformance is identified, the QC officer and project manager will meet to determine possible causes for the nonconformance and to formulate corrective actions. Corrective actions resulting in a change to the design will be submitted on a fieldwork variance form to USACE and/or its designated representative(s) for approval prior to implementing the change.

Each nonconformance will require one or more corrective actions (for example, modification of component, returning materials to vendors, removing and replacing the nonconforming component, or reinstallation of the component). A nonconformance component may be deemed acceptable “as-is” only if approved by USACE and/or representative(s) by a fieldwork variance form. Any nonconformances will reinitiate the entire three-phase QC process from the preparatory phase through the follow-up phase.

9.1.3 Daily Reporting

Following each day of the RI activities, Daily Quality Control Reports will be prepared and submitted to USACE. QC activities reported in the DQCR will include topics discussed at the safety tailgate meetings, safety checks of equipment, inspections performed, results of control activities, and materials received. The reports will be compiled in accordance with EM 200-1-3 Appendix F and sent to the USACE project manager at a frequency established between the USACE project manager and CH2M HILL project manager (for example, weekly) in the event that no problems or deviations from the schedule arise. However, should problems arise, CH2M HILL will notify the USACE project manager immediately and send the Daily Quality Control Reports daily by electronic mail, telefax, or express mail until the problem has been corrected.

10. Nonconformance and Corrective Actions

Section 10 describes the corrective actions to be taken if field personnel discover a discrepancy during a desk or field audit, or if the laboratory discovers discrepancies or problems. Typical discrepancies include improper sampling procedures, improper instrument calibration procedures, incomplete or improper sample preservation, and problems with samples upon receipt at the laboratory.

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-QC performance that can affect data quality. Corrective action can be taken during field activities, laboratory analyses, data validation, and data assessment. Corrective action proposed and implemented will be documented in regular QA reports to management. Corrective action should be implemented only after approval by the project manager or a designee. If immediate corrective action is required, approvals secured by telephone from the project manager should be documented in an additional memorandum.

For noncompliance problems, a formal corrective action program will be determined and implemented at the time the problem is identified. The person who identifies the problem will be responsible for notifying the project manager, who in turn will notify the USACE Contracting Officer's Representative. Implementation of corrective action will be confirmed in writing through the same channels.

Noncompliance with the established QC procedures in the UFP-QAPP or this FSP will be identified and corrected. The CH2M HILL project manager or designee will issue a nonconformance report for each noncompliance condition.

Corrective actions will be implemented and documented in the field logbook. No staff member will initiate corrective action without prior communication of findings through the proper channels. If corrective actions are insufficient, work may be stopped by a stop-work order issued by USACE.

CH2M HILL recognizes USACE's desire that data generated from the sampling effort have minimal qualifiers because of nonattainment of field and laboratory QC objectives. CH2M HILL and its subcontract laboratory will be proactive in preventing missed holding times and meeting surrogate criteria. When the criteria are not met, resampling and re-analysis may be implemented as corrective actions.

10.1 Field Corrective Action

Corrective action in the field can be needed when the sample network is changed (for example, more or fewer samples, sampling locations other than those specified in this FSP) or sampling procedures and/or field analytical procedures require modification because of unexpected conditions. Technical staff and project personnel will be responsible for reporting suspected technical or QA noncompliances or suspected deficiencies of an activity or issued document by reporting the situation to the project manager or designee. The project manager is responsible for assessing the suspected problems in consultation with the project QA manager on making a decision based on the potential for the situation to affect the quality of the data. If the situation represents a reportable noncompliance requiring corrective action, then the manager will issue a noncompliance report.

The manager will ensure that corrective actions for noncompliances are initiated by the following:

- Evaluating reported noncompliances
- Controlling additional work on nonconforming items
- Determining disposition or action to be taken
- Maintaining a log of noncompliances
- Reviewing noncompliance reports and corrective actions taken
- Ensuring that noncompliance reports are included in the final site documentation in project files

If appropriate, the project manager will ensure that no additional work that depends on the noncompliant activity is performed until the corrective actions are completed. Corrective action for field measurements may include the following:

- Repeat the measurement to check the error
- Check for proper adjustments for ambient conditions such as temperature
- Check the batteries
- Recalibrate the equipment
- Check the calibration
- Replace the instrument or measurement devices
- Stop work (if necessary)

The FTL or designee is responsible for RI field activities. In this role, the FTL must at times adjust the site programs to accommodate site-specific needs. When it becomes necessary to modify a program, the responsible person notifies the FTL of the anticipated change and then implements the change upon the FTL's approval. The change in the program will be documented on the field change request that will be signed by the initiators and the FTL. The field change request for each document will be numbered serially as received. The field change request will be attached to the file copy of the affected document. The FTL must approve the change in writing or verbally prior to field implementation, if feasible. If unacceptable, the action taken during the period of deviation will be evaluated to determine the significance of the departure from established program practices and action taken.

The FTL is responsible for the controlling, tracking, and implementation of the identified changes. Reports on changes will be distributed to affected parties. The contracting office representative will be notified whenever program changes are made in the field.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected as a result of unapproved or improper use of approved methods. The QA officer will identify deficiencies and recommended corrective action to the project manager. The FTL and field team will implement corrective actions. Corrective action will be documented in QA reports distributed to the entire project management team.

Corrective actions will be implemented and documented in the field logbook. No staff member will initiate corrective action without prior communication of findings through the proper channels. If corrective actions are insufficient, USACE may stop work.

10.2 Laboratory Corrective Action

Corrective action in the laboratory may occur before, during, and after initial analyses. Laboratory corrective actions are defined in Worksheet #25 of the UFP-QAPP.

11. References

CH2M HILL. 2012. *Draft Quality Control Plan*. *RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway), St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri*. October.

U.S. Army Corps of Engineers (USACE). Kansas City District. 2012. *Scope of Work, Operable Unit (OU) 2 –Vapor Intrusion Pathway, St. Louis Ordnance Plant-Former Hanley Area, Installation Restoration Program*. April 27.

USEPA. 1999. *Compendium Method TO-15 Determination Of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS).* EPA/625/R-96/010b. January.

Attachment A
Standard Operating Procedures

STANDARD OPERATING PROCEDURE

Soil Boring Logging

Purpose and Scope

This standard operating procedure (SOP) provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations. The logging of soil samples will be conducted in accordance with ASTM International (ASTM) Designation D2488-00: *Standard Practice for Description and Identification of Soils* (*Visual-Manual Procedure*).

Equipment and Materials

- Soil boring log forms
- Soil logging guide
- Field logbook
- Camera
- Dry erase board and marker
- Clean plastic sheeting
- Clean Department of Transportation (DOT)-approved 55-gallon steel drum and label
- Tape measure
- Pocket pentrometer
- Photoionization detector (PID)
- Sealable plastic bags
- Clean latex or nitrile gloves

Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log (attached) and field classification of soil procedures.

Instructions for Completing Soil Boring Logs

Soil boring logs will be completed on the CH2M HILL soil boring log. The information collected in the field to perform the soil characterization is described below. Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Analytical samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

Heading Information

Boring Number. Enter the boring number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each location.

Location. If station, coordinates, mileposts, or similar project layout information are available, indicate the position of the boring to that system using modifiers such as “approximate” or “estimated” as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities.

Contractor. Enter name of the company and the city and state where it is based.

Drilling/Excavation Method and Equipment. Identify the bit size and type and method of drilling (for example, rotary, hollow-stem auger). Information on the drilling equipment (for example, CME 55, Mobile B61) also is noted. For excavations, enter type of equipment used (such as make/model of equipment).

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole/excavation. If free water is not encountered during drilling/excavation or cannot be detected because of the drilling method, this information should be noted. Record date and time of day of each water level measurement.

Date of Start and Finish. Enter the date(s) and time(s) the boring/excavation was begun and completed.

Logger. Enter the first initial and full last name.

Technical Data

Depth Below Ground Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material (such as slough) in the measurement. Record recovery in feet.

PID. In this column, enter the headspace reading of the sample interval. PID measurements are to be conducted in accordance with the SOP, *Organic Vapor Monitor*.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (rod drops, rod bounce as in driving on a cobble, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders). Such information should be attributed to the driller and recorded in this column.

Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D2488, *Visual-Manual Procedure for Description and Identification of Soils*.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "Sandy CLAY."
2. Group symbol, in parentheses, for example, "(CL)."
3. Color, using Munsell color designation.
4. Moisture content.
5. Relative density or consistency.
6. Soil structure, mineralogy, or other descriptors.

This order follows, in general, the format described in ASTM D2488.

Soil Name

The basic name of a soil should be the ASTM D2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is Silty SAND with gravel, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is Sandy SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D2488. There is no need to further document the gradation; however, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as “Interlayered Sand and Silt,” should be used. In addition, the relative proportion of each soil type should be indicated.

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D2488.

Group Symbol

The appropriate group symbol from ASTM D2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D2488, dual symbols (for example, GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (for example, GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group.

Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet.

Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D1586). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the “Comments” column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values.

Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D1586.

Key Checks

- Check entries between the soil boring log and field logbook in the field for accuracy
- Check entries between soil boring logs for consistency and accuracy in describing the same lithologic units.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in the SOP, *Decontamination of Drilling Rigs and Equipment*.

Attachment

- Soil Boring Log

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	PID (ppm)	DESCRIPTION	COMMENTS
				SOIL TYPE, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, MINEROLOGY, ODOR OR DISCOLORATION	DEPTH OF SURFACE CASING, DRILLING RATE, DRILLING FLUID LOSS, START/STOP TIME OF DAILY DRILLING RUNS, SAMPLE DEPTHS

STANDARD OPERATING PROCEDURE

Monitoring Well Installation and Development

Purpose and Scope

This standard operating procedure (SOP) provides field personnel with a review of the monitoring well installation procedures that will be performed. These procedures are to be considered general guidelines and are not intended to supplement or replace the contractual specifications with the subcontractor. The wells will be installed in accordance with the Missouri Well Construction Rules (10 *Code of State Regulations* [CSR] 23-1.010 through 6.060).

Equipment and Materials

- Missouri well installers permit
- Field logbook
- Clean Department of Transportation (DOT)-approved 55-gallon steel drums with labels
- Equipment/instrument decontamination materials (see SOP, *Decontamination of Personnel and Equipment*)
- Drill rig equipped with tooling for hollow-stem auger drilling methods
- Well construction materials including but not limited to slotted polyvinyl chloride (PVC) screen, PVC riser, concrete, sand, bentonite chips, bentonite granules, well cap, lock, and flush-mount well protector
- Water level meter
- Whale pump or other type of submersible high flow rate pump
- Disposable polyethylene tubing
- Groundwater quality meter capable of measuring groundwater quality parameters including temperature, specific conductivity, turbidity, and pH
- Bailer or surge block for well development with cord/string
- Clean latex or nitrile gloves

Procedures and Guidelines

The procedures and guidelines presented in this SOP discuss the installation and development of monitoring wells.

Monitoring Well Installation

- Monitoring wells will be installed in accordance with the Missouri Well Construction Rules (10 CSR 23-1.010 through 6.060). CH2M HILL personnel overseeing the installation of wells in Missouri must possess a Missouri restricted well installer permit.
- Monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes drilled using hollow-stem auger drilling techniques. In accordance with the Well Construction Rules, the diameter of the borehole must be 4 inches larger than the outside diameter of the riser pipe and screen.
- Monitoring wells will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC riser and screen with a threaded bottom plug. The threaded connections will be watertight.

Well screens will be constructed of 10-slot Schedule 40 PVC and will be at least 5 feet long. The exact length of the screen will be determined by the subsurface lithology and/or water table.

- The filter pack shall consist of silica sand and shall extend from the bottom of the hole to between 1 and 5 feet above the top of the well screen. For the purpose of the RI, the sand filter pack will extend 2 feet above the well screen. The filter pack can be a minimum of 6 inches above the top of the well screen for shallow wells (for example, wells used for the purpose of collecting groundwater within 5 feet of ground surface) in order to meet the sealing requirements. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. If the screen is set more than 25 feet into the saturated zone, the filter placement must be by tremie pipe, unless hollow-stem augers are used.
- Care must be exercised to ensure that the well screen and sand filter pack of the deeper colocated well do not overlap with the bottom of the shallow well (if applicable).
- A bentonite seal will be installed atop the sand filter pack. The bentonite seal will consist of a minimum 2 feet of bentonite chips or pellets. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape.
  - When placing the bentonite seal in the saturated zone, only chipped or pelletized bentonite may be used.
  - If the bentonite seal is located above the unsaturated zone, the bentonite chips or pellets will be hydrated in place using potable water.
  - The top of the bentonite seal will be measured after it has been allowed to hydrate and before the annular seal is applied.
- The annular seal shall be placed directly over the bentonite seal and must extend from the bentonite seal to the base of the surface completion. The type of grout used for the annular seal will consist of high solids sodium bentonite slurry, at least 20 to 30 percent weight by solids. The grout will be pumped into the annular space in one continual operation using a side-discharge tremie pipe. The combined annular seal and bentonite seal must be at least 2 feet thick. When installing a monitoring well for shallow monitoring (e.g., collection of groundwater samples within 5 feet of ground surface), the combined thickness of the annular seal and bentonite seal must be at least 1 foot thick.
- For flush-mounted well completions, the flush-mount assembly must be at least 8 inches long and have a lockable watertight cap. The riser pipe of the well must be cut off at least 2 inches below the top of the flush-mount assembly to allow room for the watertight cap. The flush-mount assembly must be set into a hole that is at least 8 inches in diameter larger than the diameter of the assembly itself and set in concrete. If the well is being placed through asphalt or concrete, a hole that is at least 4 inches in diameter larger than the diameter of the flush-mount assembly must be drilled. The assembly must then be set in concrete. Where heavy traffic may pass over the well or for other reasons, the concrete pad and valve box/lid assembly shall be constructed to meet the strength requirements of surrounding surfaces. The concrete pad will be finished in such a manner such that surface water drains away from the completion.
- Monitoring wells shall be secured as soon as possible after drilling. Corrosion-resistant locks should be used. The locks must either have identical keys or be keyed for opening with one master key.
- Drilling equipment shall be decontaminated between borehole locations (see SOP, *Decontamination of Drill Rigs and Equipment*).
- A record of the constructed monitoring well will be completed by the drilling company and submitted to Missouri Department of Natural Resources Geological Survey and Resource Assessment Division.

- Soil and liquid materials generated during well installation will be containerized in steel 55-gallon drums for characterization and disposal. CH2M HILL will label the drums in accordance with the field sampling plan. The drums will be staged in a temporary drum staging area.
- Write the new well identification on the well cap and protector. Set a survey flag adjacent to the well pad to ease the surveyor's job of distinguishing new wells from old.

Monitoring Well Development

The purpose of monitoring well development is to remove fine-grained material from the well screen and filter pack that may interfere with analyses and return the monitoring zone to its original hydraulic state, which was disturbed during well installation. Development also will redistribute the sand grains within the filter pack to allow for coarser sand material to congregate near the slotted screen. The well should be capable of producing clear water samples using appropriate sample methods; however, when wells are completed in a silty or clayey soil or the well screen straddles the groundwater surface, the groundwater discharged from the well may never clear up (that is, turbidity readings less than 10 nephelometric turbidity units [NTUs]). The following procedures and guidelines shall be followed during well development:

- New monitoring wells will be developed after the well has been installed and no sooner than 24 hours after well installation.
- Field equipment and supplies shall be placed on clean plastic sheeting to minimize contamination of the materials.
- Measure depth to groundwater in accordance with the SOP, *Water Level Measurements*.
- The well will be developed using bailers or pumps. Nondisposable equipment to be placed in the well will be decontaminated before use in accordance with the SOP, *Decontamination of Personnel and Equipment*.
- Development includes surging the well throughout the development process by rapidly moving the bailer or surge block up and down, or abruptly stopping pump flow and allowing water in the well column to fall back into the well. Pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Monitoring wells must be developed until water representative of the formation is discharged. The volume of groundwater removed from the well during development shall be a minimum of five times the well volume, including the volume of water in the sand filter pack (assume 30 percent porosity). This volume also should take into consideration the volume of fluid lost to the formation during drilling or added to the well during development (if any).
- Groundwater parameters including temperature, pH, turbidity, and specific conductivity will be measured between well volumes using a water quality meter capable of measuring these parameters.
- Well development will be continued until the required well volume is removed and the well water parameters have stabilized according to the following conditions:
  - The temperature, pH, and specific conductivity have stabilized to ± 1 degree Celsius (°C), ± 0.1 pH units, and ± 5 percent milliSiemens per centimeter, respectively, over three consecutive readings (10-minute interval readings) at a pumping rate no less than the pumping rate used for sampling (approximately 0.5 liter per minute).
  - The turbidity remains within a 10 NTU range below 25 NTUs for at least 30 minutes, and other parameters have stabilized to above criteria.
  - If, after 3 hours of purging, the turbidity is below 25 NTUs, but has not stabilized within the 10-NTU range, **and** other parameters have stabilized to the above criteria, then the well will be considered developed.

- A well also will be considered developed if it is purged dry.
- Field equipment shall be decontaminated in accordance with the SOP, *Decontamination of Personnel and Equipment*.
- Development water will be containerized in steel 55-gallon drums. The drums will be labeled in accordance with the field sampling plan and transported to the temporary drum staging area.

Key Checks

Monitoring Well Installation

- Ensure that drill rig and equipment is properly decontaminated prior to beginning work and between borehole locations.
- Verify the depths to the bottom of the borehole, top of sand pack, top of bentonite seal, top of annular seal; length of end cap, screen, and riser; and amounts of sand and bentonite used during installation with the subcontractor. Log this information in the field logbook and/or the monitoring well construction form. Confirm that the methods used during well installation are in accordance with this SOP.
- Ensure that the well completion is installed properly and will not interfere with site operations.

Monitoring Well Development

- If using a pump for monitoring well development, ensure that it is in proper working order.
- Inspect all equipment or materials to be inserted into the well as to make sure they are clean and will not compromise the integrity of the well.
- When surging the well, ensure that the bailer or surge block is moved across the entire length of the well screen.

Attachments

- Monitoring Well Development Log
- Monitoring Well Completion Diagram: Flush-Mount Completion

PROJECT NUMBER	WELL NUMBER SHEET OF

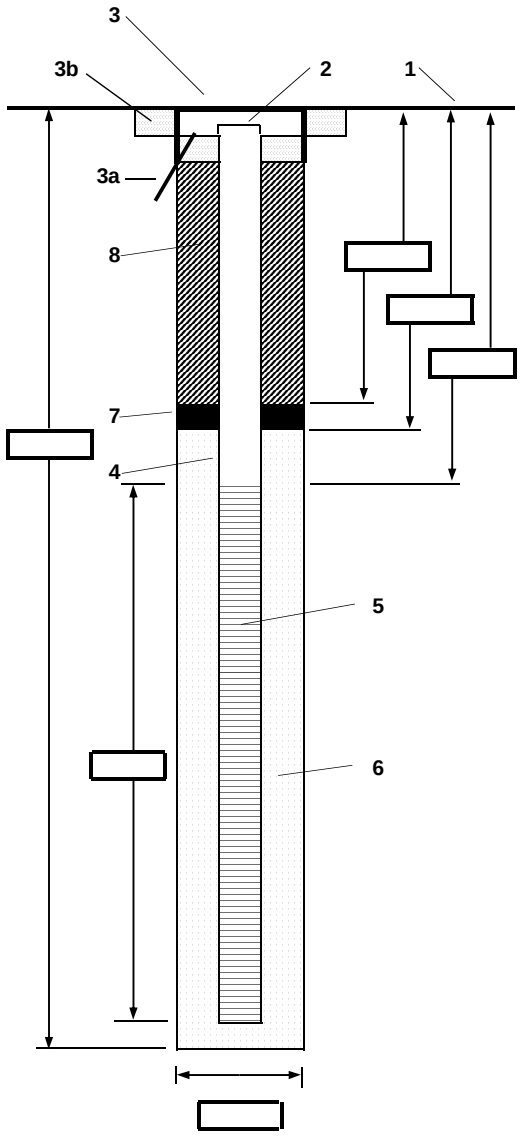
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____

3- Wellhead protection cover type _____
a) drain tube? _____
b) concrete pad dimensions _____

4- Dia./type of well riser _____

5- Type/slot size of screen _____

6- Type screen filter _____
a) Quantity used _____

7- Type of seal _____
a) Quantity used _____

8- Grout
a) Grout mix used _____
b) Method of placement _____
c) Vol. of well casing grout _____

Development method _____

Development time _____

Estimated purge volume _____

Comments _____

PROJECT NUMBER	WELL NUMBER SHEET OF

WELL DEVELOPMENT LOG

PROJECT : LOCATION :

DEVELOPMENT CONTRACTOR : LOGGER :

DEVELOPMENT METHOD AND EQUIPMENT USED :

START :

END :

START WATER LEVELS :

WELL DEPTH:

WELL VOLUME:

MAXIMUM DRAWDOWN DURING DEVELOPMENT:

TOTAL QUANTITY OF WATER DISCHARGED:

DISPOSITION OF DISCHARGE WATER:

Time	Water Volume Discharged (gal)	Water Level (ft BTOC)	Turbidity (NTU)	Temperature (°C)	pH	Specific Conductivity (mS/cm)	Remarks (color, odor, sheen, sediment, etc.)

STANDARD OPERATING PROCEDURE

Decontamination of Drill Rigs and Equipment

Purpose and Scope

This standard operating procedure (SOP) provides methods for oversight of drill and direct-push rig equipment and tooling decontamination (that is, the subcontractor is responsible for decontamination of equipment and tooling). Personnel decontamination procedures are not addressed herein. Refer to the health and safety plan and the SOP, *Decontamination of Personnel and Equipment*.

Equipment and Materials

- Field logbook
- Safety glasses, gloves, steel toe boots, hearing protection
- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Alconox or Liquinox
- Clean Department of Transportation (DOT)-approved 55-gallon steel drums and labels
- Buckets
- Brushes
- Portable decontamination pad lined with plastic

Procedures and Guidelines

- Drill rigs and heavy equipment:
  - Before the onset of drilling or direct-push activities, the equipment shall be inspected to ensure that no residual contamination is brought onsite from other job sites.
  - Drill rigs and heavy equipment will be decontaminated using a detergent solution and high-pressure hot water within a decontamination pad at an area designated by field personnel. The equipment shall then be rinsed with potable water. The decontamination pad will be designed to contain decontamination wastes and wastewaters and can be a high-density polyethylene (HDPE)-lined, bermed pad. A pumping system will be used to convey rinsate from the pad to DOT-approved 55-gallon drums.
  - Field personnel will label the drums in accordance with the field sampling plan (FSP).
- Downhole drilling tools:
  - Downhole tooling that contact environmental samples (that is, core barrels and groundwater sampling devices) will be decontaminated between sample intervals at each boring location. The tooling will be scrubbed in a clean detergent solution and rinsed with potable water.
  - Other downhole tooling such as drill rods and auger flights will be decontaminated between borehole locations. Drill rods and auger flights will be decontaminated using a detergent solution and high-pressure hot water wash within a decontamination pad at an area designated by field personnel. The tooling shall then be rinsed with potable water. The decontamination pad will be designed to contain decontamination wastes and wastewaters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey rinsate from the pad to DOT-approved 55-gallon drums.

Key Checks

- Ensure that all equipment and tooling is clean prior to beginning work at a new site or sample location.

- Ensure that the pressure washer hoses are in good condition and not damaged prior to and while conducting field activities.
- Equipment rinsate blanks will be collected for locations in which environmental samples are collected. The rinsate blank will be collected by pouring ASTM International Type II Reagent Grade water over a piece of sampling equipment and collecting the rinsate in laboratory-supplied sample containers.

Attachments

None.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

Purpose and Scope

This standard operating procedure (SOP) provides general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments. This SOP is a general description of decontamination procedures for personnel and equipment used for environmental sampling purposes. This SOP does not cover the decontamination of drill rigs or other large equipment; decontamination is discussed in the SOP, *Decontamination of Drill Rigs and Equipment*.

Equipment and Materials

- Distilled, organic-free water
- Clean plastic sheet
- Phosphate-free detergent such as Liquinox or Alconox
- Clean Department of Transportation (DOT)–approved 55-gallon steel drum and label
- 5-gallon buckets
- Brushes
- Garden spray bottles for equipment wash and rinse
- Paper towels or drying cloths
- Clean latex or nitrile gloves
- Decontamination pad lined with plastic to catch wash and rinse water

Decontamination of Personnel

Decontamination of field personnel will be performed after the completion of tasks with the potential of contamination and before leaving the exclusion zone. Personnel working in Level D personal protective equipment (PPE) must properly dispose of sampling gloves. Hands and other skin exposure points to contamination will be washed in a detergent solution and rinsed. Boots or clothing that become grossly contaminated also will be washed in a detergent solution. In the event that Modified Level D PPE is required, the following decontamination procedures will be performed:

- Wash boots in detergent solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with detergent solution, remove, and discard into a drum.
- Wash outer gloves in detergent solution, rinse, remove, and discard into the drum.
- Remove disposable coveralls (such as Tyvek suits) and discard into the drum.
- Remove inner gloves and discard.
- At the end of the workday, shower the entire body, including hair.

Decontamination of Sample Equipment

This section includes the decontamination of sample equipment (for example, stainless steel soil sampling tools, water level meter, and groundwater quality equipment) and includes the following:

- Spread plastic on the ground surface to keep clean sample equipment from touching the ground surface.
- Equipment may be decontaminated in 5-gallon buckets.
- Thoroughly scrub the sample equipment in a detergent wash solution. Do not immerse nonwaterproof electronic equipment in the wash solution as it may damage electronic components. Electronic equipment

should be wiped down with a soapy paper towel. Avoid damaging any sensors on water quality meters while washing the units.

- Provide a second and third rinse of the sample equipment to remove detergent from the equipment. Care must be taken to ensure that no detergent is left on sample equipment, particularly equipment placed in monitoring well risers, as this may affect future sampling.
- For groundwater pumps, submerge the pump in the decontamination liquids as to allow the detergent solution and rinse water to pass through interior components of the pump.
- Allow the equipment to air dry in a clean, non-dusty, environment.
- Wash and rinse decontamination buckets at the end of the fieldwork.
- Decontamination water will be containerized in 55-gallon drums staged in a designated drum staging area.

Key Checks

- Make sure equipment is thoroughly cleaned and rinsed prior to use at another sample location or site.
- Properly store equipment as to maintain cleanliness when not in use.
- Refill decontamination buckets with clean water and detergent solution at the start of each day.

Attachment

- Drum inventory forms

IDW INSPECTION FORM

	Month:			
	Week:	**Week:**	**Week:**	**Week:**
General Inspection Information				
Inspection performed by:				
Staging location:				
Date of inspection:				
Time of inspection:				
IDW Quantity and Storage				
Total number of 55-gallon drums:				
- Soil:				
- Aqueous:				
- Other (specify):				
Total number of poly tanks:				
- Tank # and volume				
- Tank # and volume				
- Tank # and volume				
- Tank # and volume				
Total number of roll-off boxes:				
- Box # and volume				
- Box # and volume				
- Box # and volume				
- Box # and volume				
Labeling				
Labels are visible on all storage containers?				
Contents clearly marked?				
Source location clearly marked?				
Accumulation start date clearly marked?				
Project name and contact clearly marked?				
Physical Condition				
Leakage?				
Deterioration of container?				
Dents or irregularities in shape?				
Bulges?				
Drum lids secured and tightly bolted?				
Storage Conditions				
Drums stored on pallets?				
Secondary containment provided?				
Sufficient aisle space between drums?				

IDW INSPECTION FORM

Comments (Include date and corrective action taken):

STANDARD OPERATING PROCEDURE

Low-flow Groundwater Sampling

Purpose and Scope

This standard operating procedure (SOP) presents general guidelines for collecting groundwater or groundwater grab samples from monitoring wells using low-recovery sampling techniques. The SOP, *Water Level Measurements*, should be consulted in conjunction with this SOP.

To avoid cross-contamination, wells will be purged and sampled such that the well having the lowest suspected contamination is sampled first, and the well having the highest suspected contamination is sampled last.

Equipment and Materials

- Field logbook
- Clean latex or nitrile gloves
- Clean Department of Transportation (DOT)–approved 55-gallon steel drums with labels
- Clean 5-gallon bucket
- Peristaltic pump with portable battery
- Water level meter
- Groundwater quality meter capable of collecting groundwater quality parameters using a flow-through cell (Horiba U-22 or similar water quality meter; capable of measuring temperature, specific conductance, dissolved oxygen, turbidity, pH, and oxidation-reduction potential [Eh, or ORP] or equivalent)
- Turbidity meter to obtain more accurate turbidity readings
- Disposable polyethylene tubing
- Disposable silicon tubing
- Measuring cup to assess flow rate
- Stopwatch
- Equipment/instrument decontamination materials (see SOP, *Decontamination of Personnel and Equipment*)
- Laboratory-supplied analytical sample containers

Water Quality Indicator Parameters

The six field indicator parameters to be monitored include dissolved oxygen, turbidity, ORP, specific conductance, pH, and temperature. Of these, dissolved oxygen, ORP, specific conductance, pH, and temperature are moderately to extremely sensitive to contact with atmospheric oxygen and will be measured in-line using a flow-through cell. Turbidity also will be measured separately to reduce the influence of suspended solids that are retained in the flow-through cell. Indicator parameters will be monitored continuously during purging and values recorded every 5 minutes.

Dissolved Oxygen, ORP, Specific Conductance, pH, and Temperature

The stabilization criteria for dissolved oxygen, ORP, specific conductance, pH, and temperature are three successive readings at 5-minute intervals (for flow rate equal to or greater than 100 milliliters per minute [mL/min]) within the following ranges:

- Dissolved oxygen: ±0.1 milligrams per liter (mg/L) for values less than 1 mg/L, or ±10 percent for values greater than 1 mg/L
- Eh (ORP): ±10 millivolts (mV)
- Specific conductance: ±1 percent of full-scale reading (instrument repeatability) or default ±20 micromhos per centimeter
- pH: ±0.1 unit
- Temperature: ±0.5 degrees Celsius (°C)

It should be noted that the parameters may not stabilize before collecting a sample in accordance with the procedures for purging a low-recovery well.

Turbidity

Turbidity is considered stabilized if values are less than 50 nephelometric turbidity units (NTU) for 3 successive readings at 5-minute intervals (assuming a 100 mL/minute flow rate). If the other parameters stabilize but turbidity remains greater than 50 NTU, field personnel should continue purging at the determined sustainable flow rate to see whether the turbidity decreases with additional pumping. If turbidity does not decrease, the project manager should be notified. It should be noted that turbidity measurements may not stabilize within the aforementioned criteria before collecting a sample in accordance with the procedures for purging a low-recovery well.

Procedures and Guidelines (Low-recovery Well)

A “low-recovery” well is a well in which stabilized water level cannot be obtained, regardless of pumping rate or equipment type. If a purge rate of 100 mL/min causes excessive drawdown or alternative equipment with flow rates less than 100 mL/minute cannot be used, the following procedure should be used:

1. Set up and calibrate instruments in accordance with manufacturer’s instructions.
2. Decontaminate sampling equipment and other instruments to be placed in the monitoring well riser before sampling in accordance with the SOP, *Decontamination of Personnel and Equipment*.
3. Before performing low-flow sampling, measure the depth to groundwater as described in the SOP, *Water Level Measurements*. **Do not measure the depth to the bottom of the well at this time** in order to reduce the possibility that accumulated sediment in the well will be disturbed. Obtain total well depth from the monitoring well development log. (If required, perform a sitewide groundwater monitoring event to obtain groundwater elevations for monitoring wells at the site.)
4. Place field equipment and supplies on clean plastic sheeting to minimize contamination.
5. Collect the following information:
   - Obtain well casing and borehole diameters.
   - Determine saturated casing volume and saturated borehole volume (casing volume + saturated filter pack volume).
   - Determine saturated casing volume above the tubing intake.
   - Determine sampling system volume (volume capacity of tubing and flow-through cell).
   - Determine volume necessary to collect required samples, including quality assurance/quality control samples.
6. Connect the silicone tubing to the peristaltic pump.

7. Slowly lower the polyethylene tubing to the top of the water column. The field team shall use a tape measure to measure out the tubing as it is lowered into the monitoring well. The tape measure should not be lowered with the tubing.
8. The tubing intake should be placed in the middle of the well screen if the entire length of the well screen is below the potentiometric surface. If the potentiometric surface is within the well screen, the intake should be set approximately 2 feet off the bottom of the well to minimize the intake of fines accumulated on the bottom of the well and maximize the length of water column above the tubing intake.
9. Cut the polyethylene tubing, secure to the top of the well riser with a clamp, and connect to the silicone tubing in the peristaltic pump. Allow for enough excess polyethylene tubing in the event that water does not recharge as fast as the pumping rate, therefore needing to lower the tubing further into the well.
10. Ensure that the pump flow direction is correct on the peristaltic pump. It is best to verify the flow direction before connecting the polyethylene tubing by inserting the silicone tubing in a cup of distilled water. Turn pump on and adjust the flow rate as to not exceed 0.1 liter per minute (0.026 gallon per minute).
11. Determine whether the saturated casing volume above the tubing intake is sufficient for at least two sampling system volumes plus required samples.

    11a. If the casing volume above the tubing intake is sufficient for at least two sampling system volumes plus required samples, purge slowly at a constant flow rate, measure and record water level and field indicator parameters every 500 milliliters (mL) until two or more system volumes have been removed, collect samples, and document conditions and procedures. (*Note:* Water level will not be stable [that is, drawdown will occur] and indicator parameters may not be stable.)

    11b. If the casing volume above the tubing intake is not sufficient for at least two sampling system volumes plus required samples, but is sufficient for at least one sampling system volumes plus required samples, purge slowly at a constant flow rate; measure and record water level and field indicator parameters every 500 mL until one (or available) system volumes have been removed; collect samples; document conditions and procedures. (*Note:* Water level will not be stable [that is, drawdown will occur] and indicator parameters may not be stable.)

    11c. If the casing volume above the tubing intake is sufficient for required samples only, determine whether it is acceptable to collect samples without purging. If this is acceptable for project purposes, collect samples at a constant flow rate without purging, document conditions and procedures.

    11d. If the casing volume above the tubing intake is not sufficient for required samples, determine whether samples can be prioritized and if it is acceptable to collect priority samples without purging. If this is acceptable for project purposes, collect the priority samples at a constant flow rate without purging, and document conditions and procedures.

    11e. If the casing volume above the pump intake is not sufficient for required samples, samples cannot be prioritized, or it is unacceptable for project purposes to collect samples without purging, do not sample and document conditions.

    11f. If the well cannot be sampled using the low-recharge procedure, determine whether the well can be removed from the monitoring network.

12. Turn on the groundwater parameter field instrument and let the readings stabilize. Once temperature has stabilized for 30 seconds, record initial groundwater parameters and depth to groundwater on a groundwater purging and sampling form.
13. Purged groundwater can be initially containerized in a plastic 5-gallon bucket and subsequently transferred to a clean 55-gallon steel drum.
14. If the well was purged, disconnect the polyethylene tubing from the flow-through cell. **Groundwater samples must never be collected from the outlet of the flow-through cell.** When collecting samples, ensure that the

flow rate of the pump is equal to or less than the flow rate used to purge the monitoring well. If the well was unable to be purged, groundwater samples shall be collected after pumping begins. Collect groundwater samples directly from the outlet of the polyethylene tubing starting with volatile organic compound (VOC) samples first. VOC samples shall be collected in accordance with the SOP, *Water Sample Collection for VOCs*.

15. Following the collection of groundwater samples, label the sample containers and place the samples in an ice-bearing cooler away from sources of cross contamination.
16. Remove the tubing from monitoring well and discard. Secure the well cap and lid on the well immediately after removing the tubing to prevent objects from being dropped in the well.
17. Decontaminate all equipment and instruments in accordance with the SOP, *Decontamination of Personnel and Equipment*.
18. Store instruments in accordance with the manufacturer's instructions.
19. Purged groundwater will be handled in accordance with the field sampling plan.

Key Checks

- Ensure that the water quality meters are calibrated and cared for in accordance with manufacturer's instructions.
- Check that the flow direction switch on the peristaltic pump is in the correct direction. Flow in the wrong direction may create bubbles in the well riser, thus affecting dissolved oxygen readings.
- Charge battery to peristaltic pump and water quality meter when not in use. Low battery on the water quality meter may not allow unit to connect properly with sonde.

Attachment

- Groundwater Purging and Sampling Form

Field Data Sheets for Low Flow Ground Water Sampling

Project Name:_____ Project Number:
Sample Source (Well No./Location)_____ Date: ____/_____/_____
Weather Conditions _____
PID _____ (ppm) Condition _____
Sample Team _____

Well Stabilization Data

Well Depth _____ (FT.) Datum _____
Static Water Level _____ (FT.) Diameter :___"_____
Water Column _____(FT.) Time Purging begins (T_o):_____
Well Volume _____

Time Purging ends (T_1) _____
Water Level at time T_o _____
Water Level at time T_1 _____
Purge Method: ____Peristaltic Pump____

Time	Volume Removed	pH + / - 0.1	SPCOND.(mS/cm) + / - 3%	TEMP.(C) + / - 0.2	Redox (mV) + / - 10 mV	Water level (Ft) < 0.3 ft	D.O. (mg/L) + / - 10%	Turbidity (NTU)	Purge rate (Lpm) <0.5LPM	Appearance
	DURING SAMPLING									
	AFTER SAMPLING									

SAMPLING

Date:___/_____/_____ Analysis:
Time: _____
Field Filtering _____
Sampling Methodology _____ Low Flow Sampling
Laboratory _____ Method of Shipment _____
Remarks :_____

Groundwater Purging and Sampling Form

Project Name:_____ Project Number:_____ Sheet of
Sample Source (Well No./Location):_____ Date: ____/_____/_____
Weather Conditions:_____
Well Condition:_____
Sample Team: _____
Sample Equipment:_____

Well Stabilization Data

Datum _____ Well Volume: Time Purging begins (T_o)_____
Well Depth _____ (ft) 1V = _____(gal) Water Level at time T_o _____
Static Water Level _____ (ft) 3V = _____(gal) Time Purging ends (T_1) _____
Water Column _____(ft) 5V = _____(gal) Water Level at time T_1 _____
Diameter :___"_____ Pumping System Volume _____(gal)

Time	Volume Removed	pH + / - 0.1	SPCOND.(mS/cm) + / - 20 µmho/cm[1]	TEMP.(C) + / - 0.5	Redox (mV) + / - 10 mV	Water level (Ft) < 1.0 ft	D.O. (mg/L) + / - 10%[2]	Turbidity (NTU)	Purge rate (Lpm)	Appearance

[1] Specific conductance: +/- □1% of full-scale reading (instrument repeatability) or default +/- □20 µmho/cm
[2] Dissolved oxygen: +/- □0.1 mg/L for values < 1 mg/L, or +/- □10% for values >1 mg/L

Sample Information

Sample ID:_____
Analysis:_____
Date:___/_____/_____
Time:_____
Field Filtering:_____ Filter Type _____
Laboratory:_____ Method of Shipment:_____
Remarks:_____

STANDARD OPERATING PROCEDURE

Water Sample Collection for Volatile Organic Compounds

Purpose and Scope

This standard operating procedure (SOP) provides general guidelines for sampling aqueous volatile organic compound (VOC) samples. The standard techniques for collecting representative samples are summarized.

Equipment and Materials

- Field logbook
- Equipment/instrument decontamination materials (see SOP, *Decontamination of Personnel and Equipment*)
- Sample equipment, instruments, and materials (see SOP, *Low-Flow Groundwater Sampling*)
- Laboratory-supplied analytical sample containers
- Clean latex or nitrile gloves

Procedure and Guidelines

- Purge well, if possible, prior to collecting sampling in accordance with the SOP, *Low-Flow Groundwater Sampling*.
- When sampling, evaluate the area around the sampling point for possible sources of air contamination by volatiles. Products that may give off volatiles and possibly contaminate a sample include perfumes and cosmetics, skin-applied pharmaceuticals, automotive products (gasoline, starting fluid, windshield deicers, carburetor cleaners, etc.), and household paint products (paint strippers, thinners, turpentine, etc.).
- Keep the caps off the sample vials for as short a time as possible.
- Wear clean latex or surgical gloves.
- The flow rate of the pump should be equal to or less than the flow rate used to purge the monitoring well.
- Fill the sample vial immediately, allowing the water stream to strike the inner wall of the vial to minimize formation of air bubbles. DO NOT RINSE THE SAMPLE VIALS BEFORE FILLING.
- Fill the sample vial with a minimum of turbulence, until the water forms a positive meniscus at the brim.
- Replace the cap by gently setting it on the water meniscus. Tighten firmly, but DO NOT OVERTIGHTEN.
- Invert the vial and tap it lightly. If you see air bubbles (larger than the size of a pea) in the sample, do not add more sample. Use another vial to collect another sample. Repeat if necessary until you obtain a proper sample.

Key Checks

- Check sample area for possible sources of contamination. Do not sample down wind of vehicle exhaust or gasoline containers.
- Fill sample bottles slowly, minimize turbulence.
- Check sample bottles for air bubbles.

Attachments

None.

STANDARD OPERATING PROCEDURE

Water Level Measurements

Purpose and Scope

This standard operating procedure (SOP) provides guidelines for measuring depths to groundwater in soil borings, piezometers, and monitoring wells. This SOP also covers the topic of measuring light nonaqueous phase liquid (LNAPL) that may be present. It includes only guidelines for discrete measurements of static water levels and does not discuss the use of continuously recording loggers.

Equipment and Materials

- Field logbook
- Equipment/instrument decontamination materials (see SOP, *Decontamination of Personnel and Equipment*)
- Well keys and wrenches/T-bar
- Clean latex or nitrile gloves
- Electronic water level meter or oil/water interface probe (Solinst or equivalent) with a minimum 100-foot tape with graduations in increments of 0.01 foot or less

Procedures and Guidelines

- Set up and calibrate instruments in accordance with manufacturer's instructions.
- Decontaminate equipment/instruments in accordance with the SOP, *Decontamination of Drill Rigs and Equipment*.
- Open the protective cover.
- Unlock and remove all monitoring well caps. A minimum time of 30 minutes shall be allotted between the removal of a well cap and measuring the depth to groundwater in the same monitoring well. This will allow the groundwater surface to stabilize within the riser prior to taking a measurement.
- Slowly lower the probe into the monitoring well or soil boring until the probe just contacts the groundwater surface; the unit will respond with a tone or light signal. Make sure that the top of the riser pipe does not have a sharp edge that may damage the protective coating around the wires in the tape.
- The depth to groundwater shall be noted relative to a reference point indicated on the monitoring well riser pipe. If no reference is clearly visible, reference the northern edge of the riser pipe or soil boring. Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the field logbook.
- Water levels will be measured to the nearest 0.01 foot.
- To standardize elevations between flush-mount and aboveground monitoring wells, measure distance between the top of riser and ground surface to get depth below ground surface measurement.
- Record the condition of the concrete pad, padlock, well cap, protective cover, and bollards (if present).
- If a significant amount of time has passed since the wells were last measured (or if total well depth information is not available to the field team), the total depth of the monitoring well or soil boring should be recorded in the field logbook. The total well depth shall be measured in the same manner as the depth to groundwater.
- Decontaminate the probe and tape in accordance with the SOP, *Decontamination of Personnel and Equipment*.

If LNAPL is anticipated or encountered, an oil/water interface probe shall be used to determine the depth to the top of LNAPL and depth to groundwater. If LNAPL is encountered, a solid tone will sound from the oil/water interface probe. The probe must be lowered very slowly through the LNAPL to obtain an accurate depth to groundwater without agitating the LNAPL. When the probe passes through the LNAPL and contacts groundwater, the solid tone will change to a beeping tone. The depths to both media shall be measured in the same manner as previously discussed and recorded in the field logbook. If possible, the color and consistency of the LNAPL also shall be recorded in the field logbook.

Key Checks

- Before each use, verify that the battery of the water level meter or oil/water interface probe is charged by pressing the test button on the side of the unit.
- Verify that the unit is operating correctly by testing the probe in distilled or deionized water.
- Inspect the tape for abrasions that have may have exposed the wires. The unit will not function properly if there is a short in the wiring.

Attachments

None.

STANDARD OPERATING PROCEDURE

Conducting Building Surveys for Vapor Intrusion Evaluations

Purpose and Objectives

This standard operating procedure (SOP) presents general guidelines for conducting building surveys for vapor intrusion evaluations. A building survey is performed as part of a vapor intrusion evaluation to obtain information for development of a conceptual site model (CSM) and to prepare for vapor intrusion sampling (select optimal sampling locations and determine if there are any potential indoor sources of volatile organic compounds [VOCs]).

A CSM for vapor intrusion pathway evaluation describes potential constituent sources, migration pathways, and potential human receptors under current and/or future land uses at the site. The important building characteristics for vapor intrusion pathway evaluation include the following:

- Building use and occupancy
- Condition of the building envelope
- Presence of a basement or crawl space
- Dimensions of the building and interior compartments
- Condition of the slab and basement walls and presence of potential vapor intrusion pathways
- Type and typical operational settings of the heating, ventilation, and air-conditioning (HVAC) system
- Presence of potential indoor sources of VOCs

This SOP can be used to perform building surveys in residential, commercial, or industrial buildings. At project sites with multiple buildings, a building survey should be performed for each building that is included in the vapor intrusion evaluation.

Project-specific Considerations

- Some states include building survey procedures and forms in their regulations or guidance documents. It is the responsibility of the project team to make sure this procedure meets all applicable regulatory standards and receives approval/concurrence from the leading regulatory agency for the project.
- The building survey will likely be the first interaction with the occupants at the building and is an appropriate time to provide occupants with information on the vapor intrusion evaluation being performed and any sampling procedures that will be used. For vapor intrusion evaluations in residential areas, a community outreach plan should be developed and the field team should be trained on how to communicate with residents.
- Varying levels of detail can be attained for building surveys. The project should develop data quality objectives (DQOs) to determine what specific information should be collected for their project.
- Ideally, the building survey should be conducted at least one week before the actual indoor air or subslab soil gas sampling event. This advance timeframe allows the vapor intrusion investigator to identify and eliminate (to the extent practical) potential background sources of indoor air contamination. It also permits the investigator to confirm the sample locations with the occupants and regulatory agency(s) (if applicable) ahead of the scheduled sampling event.

Health and Safety

There are several health and safety topics to consider when performing building surveys:

- Field teams should work in pairs at residential buildings or at industrial/commercial buildings where a relationship with the building occupant has not yet been established. A field team member should never enter a building alone for the first time. The mental stability of a building occupant should not be taken for granted. Building surveys at abandoned buildings should also be performed in pairs; if one team member is injured, the other will be able to seek help.
- Walk slowly and with caution to avoid slips, trips, and falls.
- Beware of animals and insects. This applies to abandoned buildings and residences.
- Be careful of overhead hazards in basements. Do not attempt to enter crawl spaces.

Materials

- Building Survey Form to record survey information. Example forms are provided as attachments to this SOP. There is one for residential buildings, and one for industrial/commercial buildings.
- Figure showing the footprint of the building (if available) to mark up during the building survey with information about the building characteristics. It may also be helpful to ask the building contact for a copy of the fire evacuation map that will show the building footprint and interior walls.
- Flashlight.
- Walking wheel or measuring tape to measure building and room dimensions.
- Camera to photograph the building (interior and exterior), if allowed by the building owner.
- Photoionization detector to monitor total VOCs for health and safety at sites where high VOC concentrations may be expected (*OPTIONAL*).

Building Survey

- Gain access to the building. Schedule the site visit with the site contact. At a client- owned and -operated site, this step may just require a phone call to the client. At an off-site residence, this may require significant coordination, including obtaining an access agreement and providing vapor intrusion fact sheets to inform residents of the vapor intrusion pathway and the reason for the investigation.
- Obtain occupant information. The building occupants are the potential receptors in the vapor intrusion CSM. Is the building use residential, commercial, or industrial? How many people typically occupy the building? Are there sensitive receptors (children, elderly, or immune-impaired) in the building? How much time do occupants spend in the building? What areas of the building do the occupants typically use (i.e., where do they spend the most time)?
- Obtain building information. How old is the building? What was its original use? Have there been any additions or other significant modifications? Additions will likely have slabs that are separate from the original building. How many floors does the building have? Does the building have a basement? If so, how far does it extend below grade? Is the slab on grade? Is the slab elevated above the ground surface?
- Survey the building envelope. The condition of the building envelope will determine the rate of outdoor to indoor air exchange. A high rate of outdoor air exchange can dilute soil gas that may be migrating into the building. Walk around the inside and outside of the building and record information on the building construction and condition. How many doors/windows/loading docks are there, what condition are they in, and are they typically left open or closed? What are the building construction materials?
- Determine the indoor air volume and the location and volume of separate indoor air compartments within the building. If a building has a very large indoor air volume, soil gas migrating into the building may

become quickly diluted. Measure the building dimensions (length, width, and height). Measure the dimensions of compartments or rooms within the building. How are rooms connected? Are interior doors typically kept open or shut? Are there separate compartments within the building (i.e., areas that are not connected to other areas such that the indoor air does not mix)? Indoor air sampling may be necessary in multiple rooms if the indoor air volume is not connected.

- Observe the slab condition. The building slab is the barrier between subslab soil gas and the indoor air. How thick is the slab? What is the general condition of the slab? What is the floor covering in each room of the lowest floor (carpet, tile, etc.)?
- Identify potential vapor intrusion pathways. The entry of organic vapors into a structure is caused by the infiltration of contaminants through the slab and walls that are in contact with the soil. Any openings, cracks, or penetrations in the slab or basement walls may be entryways for subslab soil gas. Are there any utilities that penetrate the slab or basement walls? Are they sealed properly? Are there cracks in the slab or basement walls? If so, note where these cracks are and their approximate size. Are there sumps? If so, note the dimensions of each and their typical operating conditions. Is the wall/floor juncture sealed well? Is there a french drain? Has the basement been waterproofed? Are there expansion joints in the slab? If so, note their condition.
- Evaluate the HVAC system. The heating, air-conditioning, and ventilation (HVAC) system's operation can determine if the building is negatively or positively pressurized. If a building is negatively pressurized, then subslab gas will be pulled into the building; if the building is positively pressurized, subslab gas will not enter the building. Record the type/model of the systems and the typical operating conditions. Is there one air-conditioning zone or multiple zones (look for multiple thermostats)? Does the HVAC system use radiant heat or forced air? If the HVAC system is forced air, where are the heating/cooling and return air vents? What is the HVAC system's fresh air intake? What is the heating fuel source (i.e., natural gas, oil, propane)? Are there ventilation fans? If so, note where and their typical operating conditions. Are there window air conditioning units?
- Identify any existing vapor mitigation systems. Is there a radon mitigation system or other subslab depressurization system? Is there sealant on any cracks or crevices? Is there a sealant coat on the floor for vapor or water mitigation?
- Sketch the building floor plan. Record all pertinent building characteristics for the vapor intrusion evaluation. Include building dimensions, locations of windows/doors/loading docks, outdoor surface cover (grass, asphalt, etc.), and locations of any potential indoor VOC sources.
- Identify potential indoor contaminant sources within the building. Record the location of the potential sources and determine if they can be removed before indoor air sampling is performed. Potential indoor sources of VOCs may include cleaning products, paint, dry-cleaned clothes, gasoline, cosmetics, or cigarette smoke. Recent remodeling activities, including painting, installing new carpeting or flooring, and moving in new furniture should be identified, because they could be potential sources of VOCs. It may be necessary to include additional sheets to inventory all the potential VOC sources within the structure. Be sure to document any potential VOC sources that are removed from the structure so that it can be included in the data evaluation. When potential indoor VOC sources are identified and removed from a building, it may be necessary to ventilate the rooms affected in advance of the air sampling event. This ventilation should be completed at least 24 hours before the commencement of the indoor air sampling event. A hand-held field screening instrument can also be used to pinpoint potential indoor VOC sources.
- Identify potential outdoor contaminant sources. These may include gas stations, major roadways, dry cleaners, repair shops, industries, or landfills.
- Identify possible indoor air, outdoor air, crawl space air, and subslab soil gas sample locations that meet the project-specific DQOs. (OPTIONAL)

The selected sampling location(s) should be chosen in consultation with the property owner during the building survey.

Procedures for collecting indoor air, outdoor air, crawl space air, and subslab soil gas samples inside a building are described in the ***Standard Operating Procedure for Indoor, Outdoor, and Crawl Space Sampling for VOCs Using Canisters*** and the ***Standard Operating Procedure for Installing and Sampling Subslab Soil Gas Probes Using Canisters***.

Indoor Air Sample Locations

- Typically, indoor air samples should be collected from each compartment or HVAC zone within a building.
- Typically, indoor air samples should be collected on the lowest floor of the building at breathing zone height (approximately 3 to 5 feet) toward the center of the building away from windows.
- Consideration should be given on a case-specific basis to those situations (such as a daycare facility) where a different sampling height may also be appropriate to evaluate a unique setting or population.
- Indoor air samples should be located in the areas of the building that are occupied most frequently and by the most amount of people.
- Indoor air samples can be collected from more than one floor within a structure to address varying risk exposures and as part of the process to distinguish contaminants related to vapor intrusion from background sources. Thus, the location and position of the sample container will vary depending on which floor the sampling event takes place.
- The basement sample(s) are primarily designed to investigate “worst case” situations within a structure. Therefore, basement samples are positioned as close as possible to the source area (e.g., sumps or major cracks in the foundation).

Outdoor Air Sample Locations

- Typically, outdoor air samples are collected upwind and/or downwind of the building or site being investigated.
- Avoid biasing the sample results by placing the canister near potential outdoor VOC sources such as busy roads or gas stations.
- Outdoor air samples are typically located at least 10 feet away from buildings. However, the outdoor air canister may be placed near the outdoor air intake for the HVAC system for the building.
- Outdoor air sample canisters should be secured to an immovable structure to ensure security for sampling in public areas. A bicycle lock or piece of chain and padlock can be used. NOTE: Do not secure the canister to or close to a living tree, however, because the tree’s evapotranspiration process may release VOCs from groundwater into the vicinity. It may be a good idea to attach a label to the canister explaining that it is an environmental sample and should not be tampered with. The label can also include contact information.
- Typically, outdoor air samples should be collected at breathing zone height (approximately 3 to 5 feet).

Crawl Space Air Sample Locations

- Crawl space air samples are typically collected in locations selected to achieve adequate spatial coverage of the building’s crawl space. Sample location selection will be limited by accessibility.
- Crawl space air sample inlets should be located several feet from the opening or access point to avoid dilution by outdoor air. In cases where the crawl space is most conveniently sampled by access through crawl space vents, a sampling probe (sample delivery line made of Teflon or stainless steel) of sufficient length is attached to the inlet of the flow controller.

Subslab Soil Gas Sample Locations

- Subslab soil gas sample locations should also be toward the center of the building and ideally in an area of exposed concrete away from any penetrations in the slab. Positions near the perimeter of the slab are subject to dilution and should be avoided. As a rule, it is best to stay at least 5 to 10 feet away from any exterior wall.
- Typically, subslab soil gas sample locations are biased towards areas of the building where the highest subsurface VOC concentrations are expected.
- Typically, subslab soil gas sample locations should be spread out throughout the building to achieve adequate coverage of the entire building.
- Make sure the proposed subslab soil gas sample density is in accordance with applicable regulatory guidance documents. Recommendations about how many subslab soil gas samples to collect vary, ranging from one subslab soil gas sample for every 330 square feet (or two to three samples for every average-sized home) to one subslab soil gas sample for an average residential dwelling of 1,500 square feet; however, a lesser density for very large building is usually acceptable.
- To minimize potential damage to flooring, it may be necessary to select a location in a closet or utility room (where carpeting or tiles are less visible or not present at all).

Data Reduction and Evaluation

The information collected during the building survey can be used to develop a preliminary vapor intrusion CSM for the work plan, refine an existing CSM, select locations for indoor air and subslab samples, or to provide information to support the evaluation of the vapor intrusion pathway in a vapor intrusion evaluation or human health risk assessment.

Quality Control

Adequate time should be reserved for performing building surveys and detailed notes should be recorded at the time of the building survey.

Attachment

- Residential Building Survey for Vapor Intrusion Evaluation Form

Building Survey - Indoor Air Sampling

Project Information

Project Name: ..... Project # : .....

Survey Completed By: ..... Date: .....

Building Address: ..... Residence ID: .....

Resident and Contact Information

Name of Occupant: ..... Owner / Tenant / Other: .....

Occupant Phone #s: Home: ..... Work: ..... Cell: .....

Duration at Current Residence: ..... Best Time To Call / Visit: .....

Number of Building Occupants: Children (list ages): ..... Adults: .....

(If Rental) Property Owner Name: ..... *Owner Phone #s: Home:* .....

Owner Address: ..... *Work:* .....

Name of Interviewee for Building Survey: ..... Notes: .....

Building Construction Characteristics

Building Type: (Check box for all that apply)

- ☐ Single Family Residential
- ☐ Multi Family Residential
- ☐ Commercial
- ☐ Ranch
- ☐ Two-story
- ☐ Other (specify): .....
- ☐ Split Level
- ☐ Tri Level
- ☐ Duplex (# of other half of duplex): .....
- ☐ Apartment (# of units in Building): .....

Describe Building: (General Description, Construction Materials, etc.) .....

Approximate Age: ..... years **Approximate Area:** Total Living Space: ..... sq.ft. First Floor: ..... sq.ft.

Floors: # Floors at or above grade: .....

Which floors of the residence are utilized as living space / occupied? .....

Foundation Type: Foundation Description: (Split Foundation or Multiple Types)

Crawl Space: Yes / No .....

Slab on Grade: Yes / No .....

Basement: Yes / No Slab & Crawl Space Construction: .....

Basement or Crawl Space Details: (if applicable)

Finished Basement: Yes / No Basement Finished When: ..... Approximate Area: ..... sq.ft.

Basement or Crawl Space Floor: (Check box for all that apply)

☐ Concrete ☐ Dirt ☐ Floating (built on top of actual floor) ☐ Other (specify): .....

Foundation Walls: (Check box for all that apply)

☐ Poured Concrete ☐ Block ☐ Stone ☐ Other (specify): .....

Does the basement or crawl space have a moisture problem - dampness? (Check only one)

☐ Yes, frequently (3 or more times/year) ☐ Yes, occasionally (1-2 times/year) ☐ Yes, rarely (less than 1 time/year) ☐ No

Is the basement or crawl space ever wet - flooded? (Check only one)

☐ Yes, frequently (3 or more times/year) ☐ Yes, occasionally (1-2 times/year) ☐ Yes, rarely (less than 1 time/year) ☐ No

Building Address: ..... Date: .....

Basement or Crawl Space Details Continued: (if applicable)

Does the basement have any of the following? (Check all that apply)

☐ Floor cracks ☐ Wall cracks ☐ Floor Drain ☐ Sump pump

☐ Other hole / opening in floor (describe): .....

Is the sump pump used? Yes / No Depth of sump? ..... ft Where does the sump pump drain? .....

Describe ventilation of crawl space: .....

.....

Description of ground cover outside of building: ☐ Grass ☐ Concrete ☐ Asphalt ☐ Other: .....

Heating & Ventilation Systems

Heating System - Fuel Type: (Check box for all that apply)

☐ Natural Gas ☐ Electric ☐ Coal ☐ Fuel Oil

☐ Wood ☐ Other (specify): .....

Heating - Conveyance System: (Check box for all that apply)

☐ Forced Hot Air ☐ Electric Baseboard ☐ Wood Stove ☐ Fireplace

☐ Forced Hot Water ☐ Hot Water Radiation ☐ Heat Pump ☐ Kerosene Heater

☐ Other (specify): .....

Type of Ventilation System: (Check box for all that apply)

☐ Central air handler / blower ☐ Mechanical / ceiling fans ☐ Bathroom ventilation fans ☐ Air-to-air heat exchanger

☐ Kitchen range hood fan ☐ Other (specify): .....

Does the Residence have Air Conditioning: (Check box for all that apply)

☐ Central Air Conditioning ☐ Window Air Conditioners ☐ Other (specify): .....

Describe the current operating conditions of the HVAC system: .....

.....

Miscellaneous Information

Does the Residence have any of the following?

Septic System? Yes / Yes (but not used) / No Irrigation / Private Well? .....

Existing subsurface depressurization (radon) system in place? Yes / No Is it running? Yes / No

Is there standing water outside the residence (pond, ditch, swale)? Yes / No If so, describe: .....

Has the residence been retrofitted / weatherized with any of the following? (Check box for all that apply)

☐ Insulation ☐ Storm Windows ☐ Energy-efficient windows ☐ Other (specify): .....

Does the building have an attached garage? Yes / No If so, is a car usually parked in the garage? Yes / No

Chemicals

Have any pesticides / herbicides been applied around the building foundation or in the yard / gardens? Yes / No

If so, when - and which chemicals? .....

Has the residence had a pesticide treatment inside? Yes / No When / by whom? .....

Do the occupants of the building have their clothes dry-cleaned? Yes / No

When were dry-cleaned clothes last brought into the building? .....

Have the occupants ever noticed any unusual odors in the building? Yes / No

Describe (with location): .....

Building Address: ..... Date: .....

Miscellaneous Information Continued:

Have there been any known spills of a chemical immediately outside or inside the building? Yes / No

Describe (with location): .....

Do any of the occupants smoke inside the building? Yes / No How often? .....

Do any of the occupants use solvents at work? Yes / No Are their clothes washed at home? Yes / No

If so, when - and what rooms? .....

Within the last 6 months, has there been any painting or remodeling in the residence? Yes / No If so, when .....

What rooms, and what specifically was done? .....

Within the last 6 months, has any new carpeting been installed? Yes / No Have the carpets or rugs been cleaned? Yes / No

If so, when, what rooms, and what cleaners? .....

Consumer Products Inventory

Check consumer products that are present in the residence.

		Storage Location	Frequency of Usage	Date of Last Use
☐	Paint or Wood Finishes (spray or can)			
☐	Paint stripper / remover / thinner			
☐	Solvent cleaners (eg. spray-on oven cleaner)			
☐	Metal degreaser / cleaner			
☐	Gasoline / diesel fuel			
☐	Glues or adhesives (super glue, etc)			
☐	Air fresheners & scented candles			
☐	Laundry / carpet spot removers			
☐	Pesticides / Insecticides			
☐	Nail polish remover (acetone)			
☐	Aerosols (deodorizers, polish, cleaners)			
☐	Other:			
☐	Other:			
☐	Other:			

Describe any products that are containerized during sampling event:

.....

.....

.....

Provide any additional information that is provided by interviewee:

.....

.....

.....

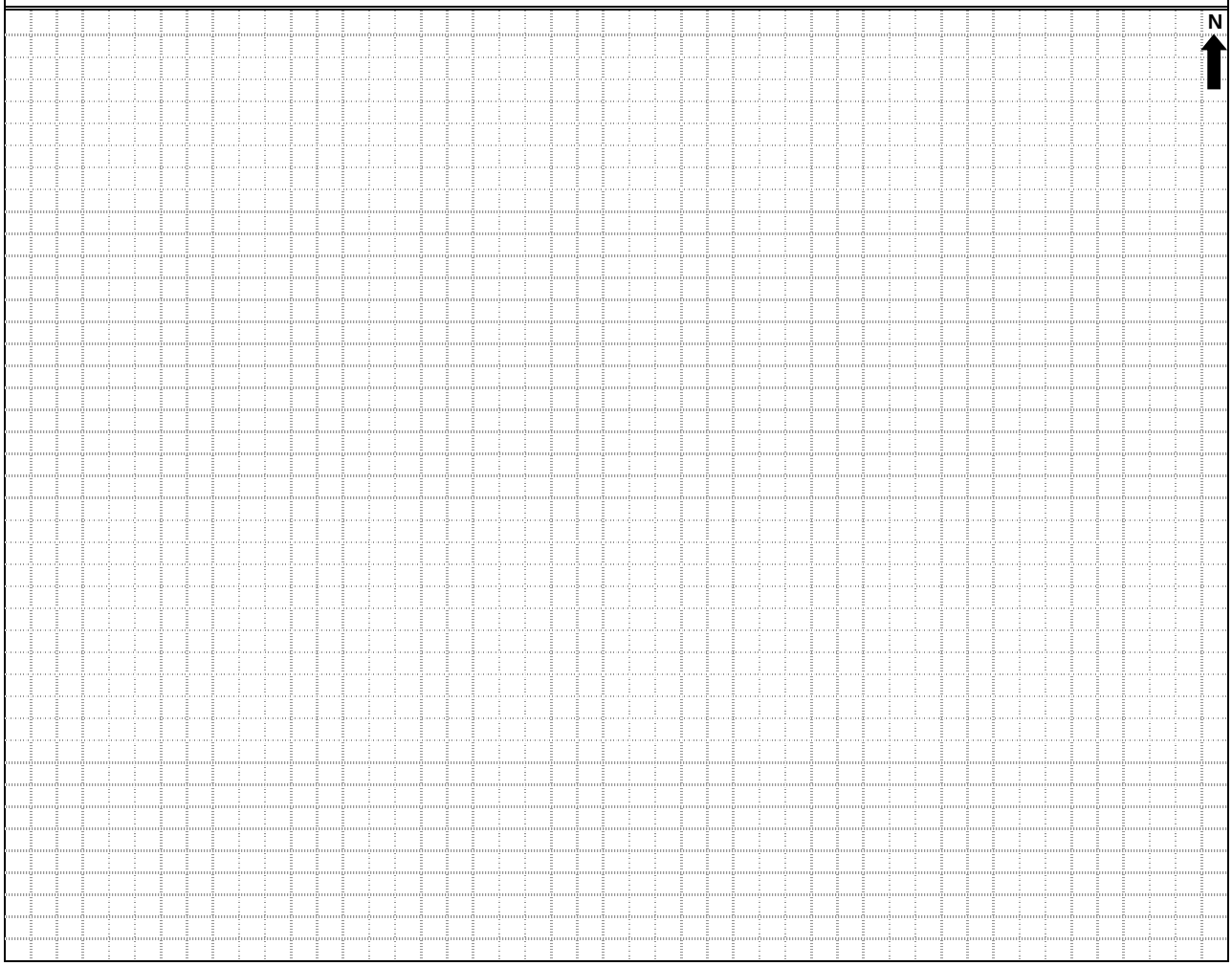
.....

Building Address: ..... Date: .....

Building Sketch

Provide sketch of floors in house, including the following information:

- Street (sidewalk, patios, driveway, distance to house)
- Primary chemical storage location(s)
- Location of heating and cooling systems, including fireplace
- General orientation of garage and main rooms
- General location of doors and windows



Post Sampling Review

Date Noted: ..... **Sampling Team:** .....

Has any information changed during the sampling event?

Did windows and doors remain closed? .....

Was any dry cleaning brought home? .....

Were any of the consumer products discussed yesterday used in the last 24-hours? .....

Were any of the containerized products opened? .....

Notes / other information observed post-sampling: .....

.....

.....

QC'ed and revised 1/17/11 KAS

STANDARD OPERATING PROCEDURE

Collection of Subslab Gas Samples Using SUMMA Canisters

Scope and Application

This standard operating procedure (SOP) describes the approach for installing subslab soil gas probes and collecting subslab soil gas samples using canisters (for example, SUMMA canisters or equivalent). It includes instructions on probe installation, leak checking, soil gas sampling, and probe abandonment. This procedure should be used in conjunction with project data quality objectives.

Project-specific Considerations

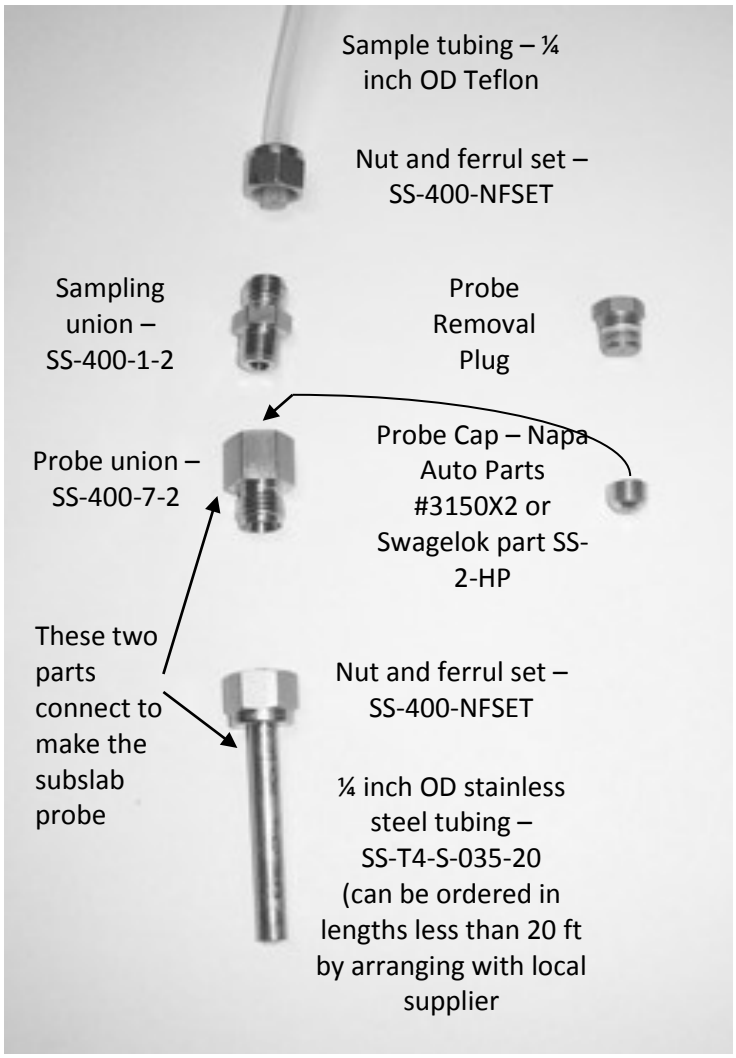
A utility clearance must be performed prior to drilling through the slab, as with all intrusive site work. In addition, it is highly recommended that ground penetrating radar (GPR), specifically a concrete scanner (small, hand-held GPR unit designed for use inside buildings), be used to identify utilities, wire mesh, and/or rebar in the slab prior to drilling. The sampling team should look around the building to locate where utilities come into the building. Utility shutoff valves should be located in case an underground utility is encountered.

Materials

Probe Installation

- Hammer drill and drill bits ($^{7}/_{8}$-inch or 1-inch and $^{5}/_{16}$-inch or ½-inch)
- Vacuum cleaner (shop-vac type or handheld) for removing concrete dust from the drilled hole; Continuously vacuum the dust as it is generated during the drilling process
- Subslab soil gas probe (for permanent and semipermanent installations); see Figure 1 for an expanded view of the probe parts
  - ¼-inch outer diameter stainless steel tube (Swagelok part #SS-T4-S-035-20)
  - Swagelok nut and ferrule (part #SS-400-NFSET)
  - Probe union (¼-inch male Swagelok to $^{1}/_{8}$-inch female NPT – part #SS-400-7-2)
  - Probe cap (Napa Auto Parts #3150X2 or Swagelok part SS-2-HP)
  - Probe seal (flush mounted hex socket plug $^{1}/_{8}$-inch PTFE coated, $^{3}/_{16}$ inch) NPT slotted brass plug) – McMaster-Carr part #4534K11
- Metal tubing cutter for adjusting the length of the probe so that it does not extend below the slab
- Probe seal consisting of Portland cement or Cement-All
- Large cotton swabs or paper towels and non-chlorinated (de-ionized or distilled) water for cleaning the concrete dust out of the hole
- Tongue depressor, putty knife, or similar tool for putting the probe seal material into the hole
- Teflon pipe tape to wrap the end of the probe tubing so that the probe fits tightly into the hole to prevent the seal material from clogging the probe
- Tape measure to measure the thickness of the slab, measured off of a long screwdriver or drill bit
- Optional: Sonicare toothbrush with bristles removed (which can be useful in removing air bubbles from the cement mixture while installing the probe thus making a more competent seal); toothpicks or Q-tips without cotton tip can also be used for this purpose

FIGURE 1
Probe Parts



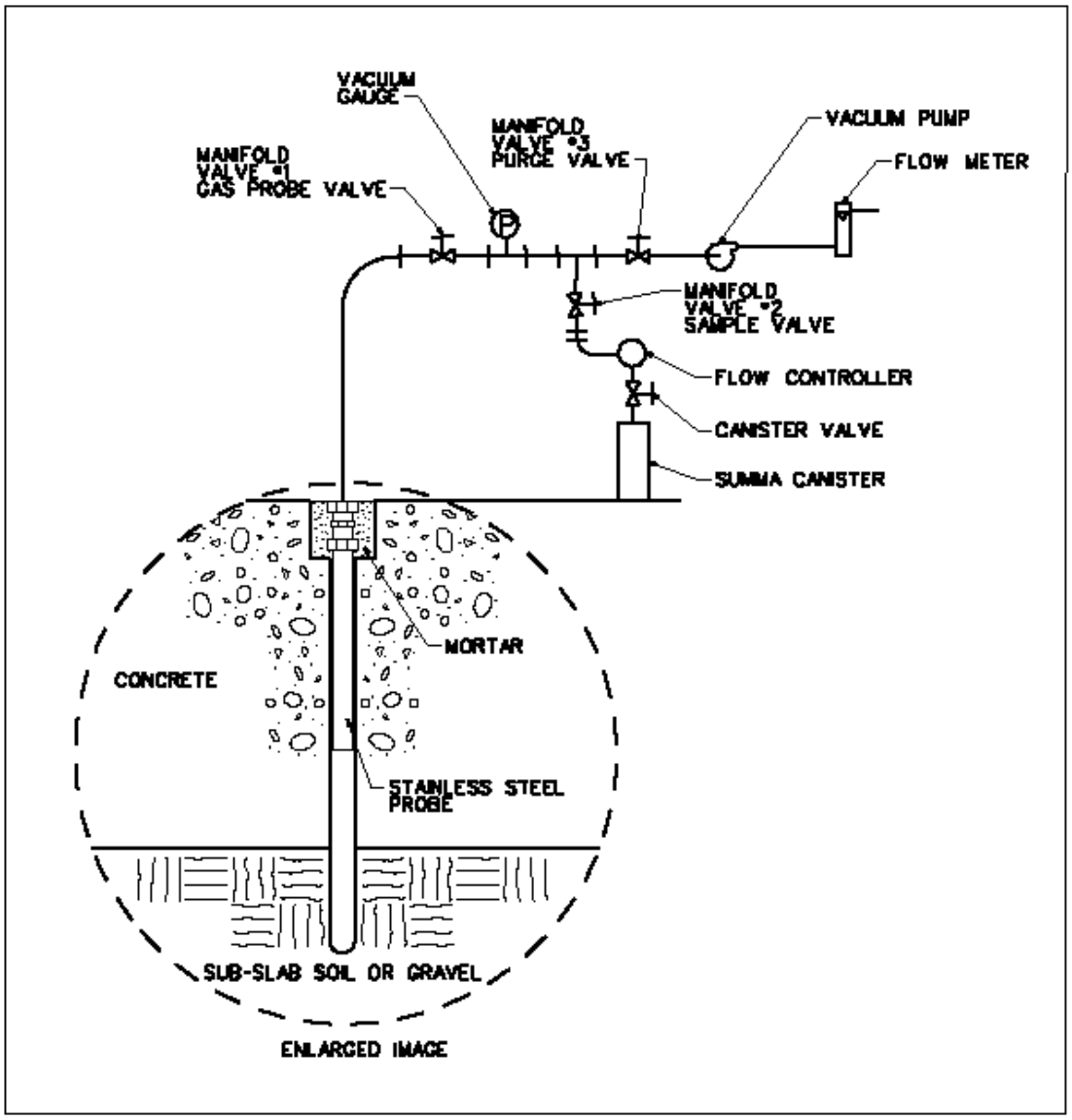
Leak Check

- Helium enclosure (may be constructed from a small bowl or container)
- Helium canister containing high grade helium (NOT balloon grade) and regulator for the canister (should be set to a flow rate of 200 milliliters per minute [mL/min] or less)
- Helium detector (for example, Dielectric MGD-2002) can be rented from an equipment rental company

Sampling

The subslab soil gas sampling setup is shown in Figure 2.

FIGURE 2
Subslab Sampling



- Sampling union (¼-inch male Swagelok or equivalent to ¼-inch male NPT—part No. SS-400-1-2)
- Vacuum pump for purging with rotometer to control flow to 200 mL/min (should be a Cole Parmer # R-79200-00 grey diaphragm pump or equivalent)
- Sampling manifold consisting of Swagelok gas-tight fittings with three valves and one pressure gauge to attach the probe to the air pump and the sample canister; see Figure 10; the manifold must be clean, free of oils, and flushed free of VOCs before use
- Swagelok valve (only necessary for extended sampling periods [for example, 8- or 24-hours] so that the sampling manifold can be disconnected without introducing indoor air into the probe) (part # SS-4P4T)
- Teflon tubing, ¼-inch outer diameter
- Tedlar bag (1-L or 3-L) to collect the purged soil gas, so: (1) it is not discharged into the building, (2) the volume of purged soil gas can be measured, and (3) field screening with a PID or GEM2000 meter can be performed on the purged gas
- Gem2000 Landfill Gas Meter—This is optional if field measurements of CO_2, O_2, and CH_4 are necessary

- MiniRae PID Meter—Used for health and safety to ensure breathing zone VOC concentrations remain below levels specified by the health and safety plan; it is also optional to collect field measurements of total VOCs from the probe or purged soil gas; may warn the lab if high concentrations are detected so they can dilute the sample before analysis
- Flow controller or critical orifice, certified clean, and set at desired sampling rate; these are typically provided and set by the laboratory; common sampling rates for subslab soil gas sampling are provided in Table 1

TABLE 1
Common Sampling Rates for Subslab Soil Gas Sampling

Can Size	Length of Sampling Time	Sampling Flow Rate (mL/min)
6 Liter	1 hour	90
6 Liter	8 hours	11.25
6 Liter	24 hours	3.75
1 Liter	5 minutes	180
1 Liter	1 hour	15
850 ml	5 minutes	150
850 ml	1 hour	12

- Canister, SUMMA polished, certified clean, and evacuated (canisters are typically provided by the laboratory)
- Miscellaneous fitting (Swagelok nut and ferrule (part #SS-400-NFSET) to connect tubing to sampling union and SUMMA canister
- Negative pressure gauge, oil-free and clean, to check canister pressure—The pressure gauges are typically provided by the laboratory. The laboratory may provide either one pressure gauge to be used with all of the canisters, or a pressure gauge for each canister to be left on during sample collection. Sometimes the canisters are fitted with built-in pressure gauges that are not removable. Gauges sent by the laboratory are for field use only, and are an approximate measure of the actual vacuum. Regularly calibrated—and less rugged—vacuum gauges are used at the laboratory to measure vacuum before shipment and again after sample receipt.

Probe Abandonment

- Probe removal fitting
- Crowbar
- Chisel and hammer
- Concrete patch (either pre-mixed cement patch or Portland cement)

Miscellaneous

- Teflon tape
- Modeling clay (VOC-free) for temporarily sealing probes that are leaking so the probe can be sampled and then patched with cement or Fix-It-All.
- Wrenches and screwdriver (clean and free of contaminants), various sizes as needed for connecting fittings and adjusting the flow controller. A $^{9}/_{16}$-inch wrench fits the ¼-inch Swagelok fittings, which most canisters and flow controllers have.

- Extension cord
- Timer/watch
- Tools required to cut carpet, and/or tools needed for removal of other floor coverings
- Shipping container, suitable for protection of canister during shipping—Typically, strong cardboard boxes are used for canister shipment. The canisters should be shipped to the laboratory in the same shipping container in which they were received.

Subslab Probe Installation

1. Locate the sampling locations in accordance with the work plan. Note the location of the probe, locations of significant features (walls, cracks, sumps, drains, etc.), and conditions of the slab and soil.
2. If needed, expose the concrete by cutting the carpet or other loose floor coverings (Note: Carpet need not be removed, but rather an "L" shape should be cut to expose the concrete for drilling and the leak check enclosure).

FIGURE 3
Drilling 3/8-inch probe hole

3. Drill a $^{7}/_{8}$-inch or 1-inch diameter hole to a depth of 1¾ inches (measured to the center of the hole) to allow room for installing the probe nut and probe union (see Figures 2 and 3). Remove the cuttings using a vacuum cleaner. Be careful to not compromise the integrity of the slab during drilling (that is, cracking it), although note if this occurs. It is important that the slab and the probe hole remain airtight for sampling and that cracks are noted.
4. Drill a $^{5}/_{16}$-inch or ½-inch-diameter hole through the remainder of the slab and approximately 3 inches down into the subslab material (Figures 2 and 4). Drilling into the subslab material creates a void that is free of obstructions that might plug the probe during sampling. Record the total depth of the slab and the depth drilled into the subslab material on the attached Sampling Log.
5. Clean out the drilled hole with the vacuum (equipped with a micro tip), cotton swabs, and paper towel. This removes any remaining dust, allowing the seal material to adhere to the hole wall better.
6. Some agencies may require that glass beads be poured into the subslab hole before installing the probe. If so, pour glass "seed beads" (available at a craft store) into the hole until enough beads have been added so that the top of the beads are even with the bottom of the slab. A thin piece of wire marked with the slab thickness and inserted into the hole can be used to determine this.

FIGURE 4
Drilling 1-inch mortar hole to a depth of 1¾-inch

7. Install the subslab probe into the hole. First, trim the probe to the appropriate length so that when inserted into the hole it will not extend below the slab. Then, wrap the end of the probe tubing with Teflon tape so that the probe fits tightly into the hole to prevent the seal material from clogging the probe. The probe is constructed of stainless steel tubing and Swagelok parts. Temporary probes consist of ¼-inch OD Teflon tubing.
8. Permanent or semipermanent installations – Wet the walls of the hole using the cotton swab or moistened paper

towel. This helps the mortar bond to the drilled concrete. Prepare the mortar in accordance with manufacturer's directions to a stiff consistency. Make sure that the consistency is such that the mixture will not run down the sides of the hole and potentially clog the probe or hole but is still easy enough to work with (so it can be easily scooped into the hole.) Only mix an amount that can be used in 15 minutes. Place sample probe and sample union part way into the hole, as shown in Figure 5. Using the tongue depressor or similar tool, apply mortar around the base of the sampling probe and sampling union such that it will be sealed once it is in place.

9. Fill the hole with mortar, and press the probe further into the hole until its top is flush with the floor. In doing so, slightly wiggle the probe to create good 'wetting' contact between the probe and the mortar as well as the mortar and the drilled concrete. It may be helpful to work the concrete with a Sonicare toothbrush (with the bristles removed) or a toothpick or similar object during this step to remove the air bubbles from the mortar and make a more competent seal. Scrape off excess and make sure there is clear access to the probe. See Figure 6.
10. Let dry for 24 hours.
11. Be sure to never leave the probe hole open to atmosphere for extended periods to minimize the effects of surface infiltration. A probe seal or cap should be inserted into the probe union to minimize the effects of surface infiltration while the sealant is drying/curing.

FIGURE 5
Installing probe with mortar

FIGURE 6
Installed probe, flush with slab

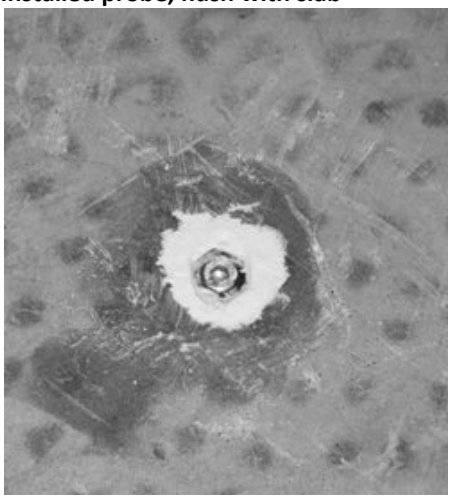
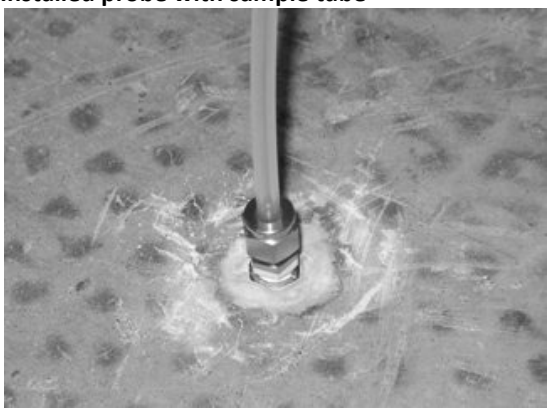


FIGURE 7
Installed probe with sample tube



System Setup

1. Remove the probe seal and attach the sampling union to the subslab probe. Then attach ¼-inch Teflon tubing to the sampling union with a Swagelok nut and ferrule set. See Figure 7.
2. Place the helium leak check enclosure over the subslab probe by threading the Teflon tubing through the hole of the enclosure. Slide the enclosure down so it seals on the concrete slab. If there is an uneven surface (for example, carpet and concrete), modeling clay can be utilized to seal the bottom of the helium enclosure to the ground surface. Attach the other end of the sample tube to the sampling manifold with the use of a nut and ferrule set. See Figures 8 to 10.
3. Attach the subslab sample tubing to the sampling manifold. See Figure 10. ***Do not connect the canister at this time***.
4. If the sample will be collected over a period of time greater than 30 minutes, a flow diversion valve (Swagelok part No. SS-4P4T) should be placed in-line between the probe and the manifold. Once purging has been completed, the flow diversion valve can be turned to the off position, allowing disconnection of

the manifold and vacuum pump for use at another location, without the loss of purge integrity at the purged location.

FIGURE 8
Installing the helium leak check assembly

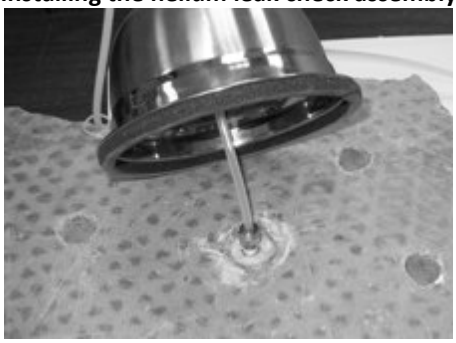
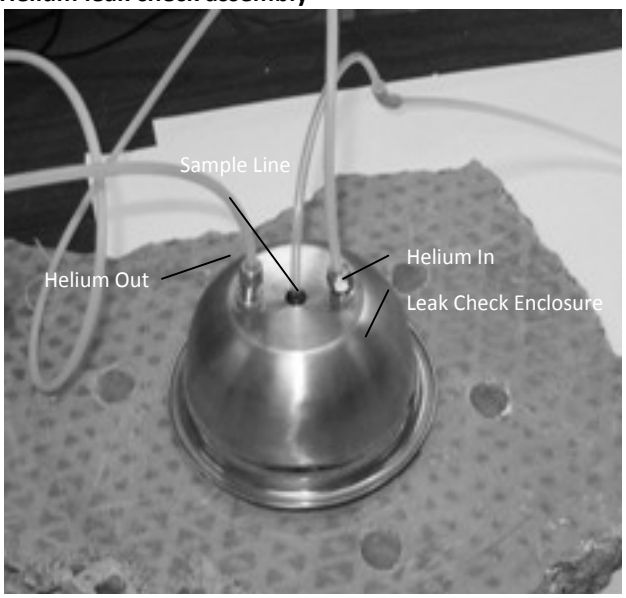


FIGURE 9
Helium leak check assembly



5. Adjust the vacuum pump to achieve the desired flow rate of 200 mL/min. This should be performed at the outlet of the vacuum pump before purging, either by using a suitable flow meter or calculating the amount of time required to fill a 1-liter Tedlar bag.
6. Attach the air pump to the sampling manifold and the Tedlar bag to the air pump exhaust.

System Leak Checking and Purging

1. Physical Leak Check—Perform a leak check of the sample manifold system by doing the following (Figure 10):

FIGURE 10
Sampling Manifold

A. Make sure the gas probe valve (valve #1) is closed and the sample valve (valve #2) is open.

B. Open the purge valve (valve #3) and start the vacuum pump. Verify that the flow is set to 200 mL/min.

C. Close the sample valve (valve #2) and achieve a vacuum gauge reading of 10 inches of mercury (Hg) or to a vacuum that will be encountered during sampling, whichever is greater.

D. A leak-free system will be evident by closing off the purge valve (valve #3), turning off the vacuum pump, and observing no loss of vacuum within the sampling manifold system for a period of 30 seconds. Repair any leaks prior to sample collection by tightening the fittings on the manifold. Re-test to make the sure the manifold passes the physical leak check before proceeding.

E. Record the leak check date and time on the field sampling log.

2. System Purge and Helium Leak Check—A purge of the subslab probe and sampling manifold system is required. The helium leak check procedure is also performed during this step. This leak check will verify the integrity of the probe seal. This is accomplished by doing the following:

A. Place the helium leak check enclosure around the subslab probe to achieve a buildup of helium in the leak check enclosure. The enclosure should not be tightly sealed and there should be an exhaust for the helium so pressure doesn't build up in the enclosure.

B. Start the flow of helium to the leak check enclosure at 200 mL/min. Try to position the tube so the helium is directed at the interface between the probe and the ground. Let the helium fill the enclosure for 1 minute.

C. Open the sample valve (valve #2) and the purge valve (valve #3) and start the purge pump. Verify that the flow rate is still 200 mL/min.

D. Open the sample valve (valve #2) and the purge valve (valve #3) and start the purge pump. Verify that the flow rate is still 200 mL/min.

E. To start the soil gas probe purge, simultaneously open the gas probe valve (valve #1) and close the sample valve (valve #2), and start timing. It is important to switch these two valves simultaneously. Otherwise, a vacuum can be built up in the sampling system, and its sudden release can draw concrete powder (left at the bottom of the probe hole after drilling) into the sampling system, which will damage the valves and vacuum pump.

F. If there is shallow groundwater in the area, carefully watch the tubing as the pump is turned on. If water is observed in the sample tubing, shut the pump off immediately. Subslab soil gas collection will not be feasible if the probe is in contact with water.

G. Connect the helium detector to the enclosure exhaust to confirm that helium is present in the enclosure during purging. It is optional to measure the helium concentration within the enclosure. Make sure that the helium detector is exposed to ambient air and "zeros out" before measuring the purged soil gas.

H. Purge the first 30 seconds (approx. 100 mL) into a 1-liter Tedlar bag. Remove the bag and replace with a fresh 1-L Tedlar bag. Continue the purge for at least another 2.5 minutes. This will result in a total of about 500 mL of purge gas in the second bag and 600 mL of purge volume total. At the end of the purge time, remove the Tedlar bag from the pump and connect it to the helium detector. The helium concentration in the purged soil gas must be less than 1 percent of what it was in the helium enclosure during purging to pass the leak test (10,000 parts per million by volume [ppmv] if the helium concentration was 100 percent) (verify that this limit is consistent with appropriate project-specific regulatory guidance). Either: (1) calculate what 1 percent of the helium concentration was in the enclosure from the

measured concentration in Step 7.2.6; or (2) use a limit of 0.1 percent (1,000 parts per million by volume [ppmv]), which allows for a 10-times safety margin. If the probe fails the leak check then corrective action is required.

I. There are three corrective action options:

i. Make sure that all the fittings are tight and add Teflon tape to them.

ii. Try fortifying the probe seal by adding more sealing material or modeling clay and repeating the purge and leak check procedure.

iii. If the above two options fail, abandon the hole, drill a new one, and repeat the whole procedure.

Note: **Helium leak detectors may be sensitive to high concentrations of methane or other atmospheric gasses.** If these are expected to be present in the subslab soil gas, then caution should be used with this technique, as false positive readings may be encountered during leak testing. Use a GEM2000 landfill gas meter to determine if methane is present in subslab soil gas.

J. If the vacuum gauge reads greater than 7 in Hg during the purge, then close the purge valve (valve #3) and monitor the vacuum in the manifold and probe. If there is no noticeable change in vacuum after a minute, then there is an insufficient amount of soil gas to collect a sample and the vacuum is too great to collect a soil gas sample. Several factors can cause this situation. Consult with the project manager and take corrective action.

i. The soil formation is too “tight” (that is, high clay or moisture content). Try using a lower flow rate.

ii. If water is visible in the flexible soil gas tubing, stop the purging immediately. It is not possible to take a soil gas sample at that depth or location.

K. At the end of the calculated purge time and after the system is verified to be leak free, close the purge valve (valve #3), close the valve to the Tedlar bag, and turn off the pump. Do not open the purge valve again. Doing so will result in loss of the purge integrity and will require re-purging. Remove the Tedlar bag and turn off the helium leak detector.

L. The purged subslab soil gas in the Tedlar bag can be screened with a GEM2000 landfill gas meter to get field measurements of CO_2, O_2, and CH_4 and/or a MiniRae PID can be used to measure concentrations of total VOCs in the field.

M. Record the purge date, time, purge rate, leak check result, and purge volume on the field sampling log.

N. Immediately move on to the sampling phase. Little to no delay should occur between purging and sampling.

Sample Collection

1. “Clean” sampling protocols must be followed when handling and collecting samples. This requires care in the shipping, storage, and use of sampling equipment. The cleanliness of personnel who come in contact with the sampling equipment is also important, so smoking, eating, drinking, perfumes, deodorants, and dry-cleaned clothing are prohibited. Canisters should not be transported in vehicles with gas-powered equipment or gasoline cans. Sharpie markers should not be used for labeling or note-taking during sampling.
2. The air sampling canisters are certified clean and evacuated by the laboratory to about 29 to 30 inches Hg vacuum. Initial canister vacuums that are less than certified by the laboratory are a potential indication of leakage that could affect the accuracy of analytical results. Care should be used at all times to prevent

inadvertent loss of canister vacuum. Never open the canister's valve unless the intent is to collect a sample or check the canister vacuum with an attached gauge.

3. Verify that the vacuum pressure of the canister is between 28 and 30 inches Hg. Do not use a canister that has an initial pressure less than 28 inches Hg because that canister likely leaked during shipment. Measure the initial canister vacuum using an external vacuum gauge, as follows:

   A. Remove the protective cap from the canister; make sure the canister valve is closed before doing this.

   B. Attach an external vacuum gauge to the canister and open the valve. If the vacuum gauge has two openings, make sure that the other opening is closed; the canister cap can be used for this. After taking the reading, record the initial vacuum, close the canister valve and remove the gauge.

   C. Measure the initial canister pressure using a digital vacuum gauge with 0.25 percent accuracy at the -30 to 0 inches Hg range and NIST-traceable calibration for vacuum measurements. See the *Technical Bulletin: Use of External Vacuum Gauges with Canisters* for a recommended model of vacuum gauge[1] for use with Summa canisters used for vapor intrusion sampling.

   D. Do not sample using a canister without sufficient initial vacuum. Be advised that sampling data may be flagged or rejected from canisters with low initial vacuum (less than 28 inches Hg). Low initial vacuum could create a low bias in analytical results due to air leakage. While there is a also a smaller risk that air leakage could introduce contaminants into the canister, the primary concern is the low bias to analytical results; this bias is within the range of analytical variability allowed with the USEPA Method TO-15 (± 30 percent) for initial vacuums greater than 24 inches Hg. The table presented below identifies the field team's response based on the initial vacuum reading for a canister. In addition, this table also identifies the potential bias to results at different initial canister vacuums.

   E. Use the following table to determine when to use canisters based on initial vacuum readings.

Initial Vacuum Reading	Potential Error in Analytical Results Due to Leakage	Field Team Response
Greater than 30 to 28 inches Hg	Up to -10% error	Use canister for sampling – no limitations on use.
Greater than 26 to 28 inches Hg	Up to -21% error	Use canister for sampling if necessary; replace canister with a spare if spares are available.
Greater than 24 to 26 inches Hg	Up to -30% error	Sampling with canister is not advisable. Contact project manager and obtain direction before sampling with this canister. Be advised that qualifiers may be applied to analytical results sampled with canisters with vacuums less than 26 inches Hg.
Less than 24 inches Hg	Greater than -30% error	Do not use this canister for sampling. Analytical results will be rejected.

4. Attach the canister to the flow controller and then connect the flow controller to the sample valve (valve #2) on the sampling manifold. Open the sample valve (valve #2)

5. Before taking the sample, confirm that the sampling system valves are set as follows:

   – The purge valve (valve #3) is confirmed to be closed, gas probe valve (valve #1) is open
   – The sample valve is (valve #2) is open.

[1] A PG5 Digital Pressure Gauge from Automation Products Group (APG), Inc.(http://www.apgsensors.com/products/pressure-sensors/digital-pressure-gauges/pg5) with National Institute of Standards and Technology (NIST)-traceable calibration certificate, or equivalent, is recommended for making vacuum measurements.

5. Slowly open the canister's valve approximately one full turn.
6. After sampling for the appropriate amount of time (determined from the work plan; see Table 1), close the sample valve (valve #2) and the canister's valve. If the canister has a built-in or assigned pressure gauge, allow the canister to fill until the vacuum pressure reaches 2 to 10 inches Hg for 6-liter canisters and 2 to 5 inches Hg for 1-liter canisters. Check the sample canister before the durations shown in Table 1 to ensure that the canister does not reach atmospheric pressure. Remove the canister from the sampling manifold.
   - If sampling for extended periods of time (for example, 8 or 24 hours), check the samples at some point several hours before the expected completion time (for example, at 18 or 20 hours for a 24-hour sample) to make sure the canister is collecting at the expected rate. It may also be a good idea to check the canister several hours into the sampling period (for example, 2 or 4 hours for a 24-hour sample). The flow controllers are rarely set to the exact sampling period.
8. If using an external vacuum gauge, re-attach it, open the canister valve, and record the final pressure. Close the valve, remove the gauge, and replace and tighten the cap on the canister. Ideal final vacuum pressure in the canister is between 2 and 10 inches Hg (6 L) or 2 and 5 inches Hg (1 L). More than 10 (5) inches Hg can greatly increase reporting limits; however, a small amount of vacuum pressure should be left in the canister so the laboratory can confirm that the canister was not opened during shipment.
9. Consult with the project manager before submitting the sample to the laboratory if a final vacuum greater than 10 inches Hg, or less than 2 inches Hg are encountered. Use the following table for guidance to determine how to address final vacuum measurements.

Final Vacuum Reading	Field Team Response
Less than 2 inches Hg	Contact Project Manager before submitting sample. Notify analytical laboratory to report their laboratory-measured pressure and to get direction from the project manager before analyzing sample.
Greater than 2 inches Hg and less than 10 inches Hg	Submit sample for analysis—no limitations on data use
Greater than 10 inches Hg	Contact project manager before submitting sample. Verify final vacuum with the analytical laboratory before analysis.

10. Canisters with no vacuum left (that is, 0 inches Hg) should not be analyzed. Contact the project manager before submitting a sample with a final vacuum of 0 inch Hg to determine the appropriate course of action. One option is to verify the final vacuum with the analytical laboratory. If there is vacuum remaining in the canister according to the laboratory vacuum gauge, the Project Manager may direct the analytical laboratory to analyze the sample.
11. The analytical laboratory should be directed to not analyze a sample showing a final vacuum of 0 inch Hg (as measured by the laboratory), and to notify the project manager and obtain further guidance regarding that sample.
12. If the flow controller is going to be used for more than one sample collection, be sure to purge it between uses. To do this, attach the flow controller to a vacuum source and draw clean air or gas (ultra-high purity) through it for several minutes before attaching it to the canister.
13. Record the sampling date, time, canister identification (ID), flow controller ID, and any other observation pertinent to the sampling event on the attached Sampling Log. Also record the weather conditions (temperature, barometric pressure, precipitation, etc.) during sampling.
14. Fill out all appropriate documentation (sampling forms, sample labels, chain of custody, sample tags, etc.).
15. Disassemble the sampling system.

16. For permanent probes, replace the probe cap and make sure it is securely in place.
17. Evacuate the Tedlar bags. Be sure this is done outside.

Sample Handling and Shipping

1. Fill out all appropriate documentation (chain of custody, sample tags) and return canisters and equipment to the laboratory.
2. The canisters should be shipped back to the laboratory in the same shipping container in which they were received. The samples do not need to be cooled during shipment. DO NOT put ice in the shipping container.
3. When packing the canisters for shipment, verify that the valve (just past finger tight) and valve caps are snug (¼ turn past finger tight), and use sufficient clean packing to prevent the valves from rubbing against any hard surfaces. Never pack the cans with other objects or materials that could cause them to be punctured or damaged.
4. **Do not place sticky labels or tape on any surface of the canister.**
5. Place a custody seal over the openings to the shipping container.
6. Make sure to insure the package for the value of the sample containers and flow controllers if corporate card policy does not cover this.
7. Ship canisters for overnight delivery.

Probe Advancement and Removal

1. After sampling, it is critical that the probe either be removed or plugged to prevent the creation of a new pathway for vapor intrusion.
2. If the probe is to be used again in the future, wrap the probe seal insert with Teflon tape and tighten it into the probe opening, using a hex key, until it is tight and flush with the concrete floor.
3. If the probe is to be removed, insert the removal fitting into the probe. Using a crow bar, remove the entire probe assembly. If this does not work, use a hammer and chisel to remove the concrete and loosen the probe. If the probe cannot be removed in this manner, then over drill the probe with a rotary hammer drill and 1-inch drill bit.
4. Fill the hole with Portland cement mix and return the surface as near to pre-sampling conditions as possible.

Quality Control

1. Canister supplied by the laboratory must follow the performance criteria and quality assurance prescribed in USEPA Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking.
2. Flow controllers supplied by the laboratory must follow the performance criteria and quality assurance prescribed in USEPA Method TO-14/15 for flow controller cleaning and adjustment.

Attachment

- Subslab Soil Gas Sampling Log—Canister Method

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Indoor Vapor Intrusion Assessment
Sub-slab Vapor Field Sampling Log - Summa Canister Method

Project Info

Project Name: _____ **Project # :** _____

By: _____ **Date:** _____

Structure

Identification: _____

Address: _____

Slab Information:

☐ Concrete slab on grade (directly on top of soil) ☐ Other (describe) _____

☐ Concrete slab on gravel underlayment _____

Condition of slab _____

Type of Sub Slab Soil _____

Is water present in the soil _____

Sub-slab Probe Installation, Leak Checking, Probe Purging, & Sampling Log

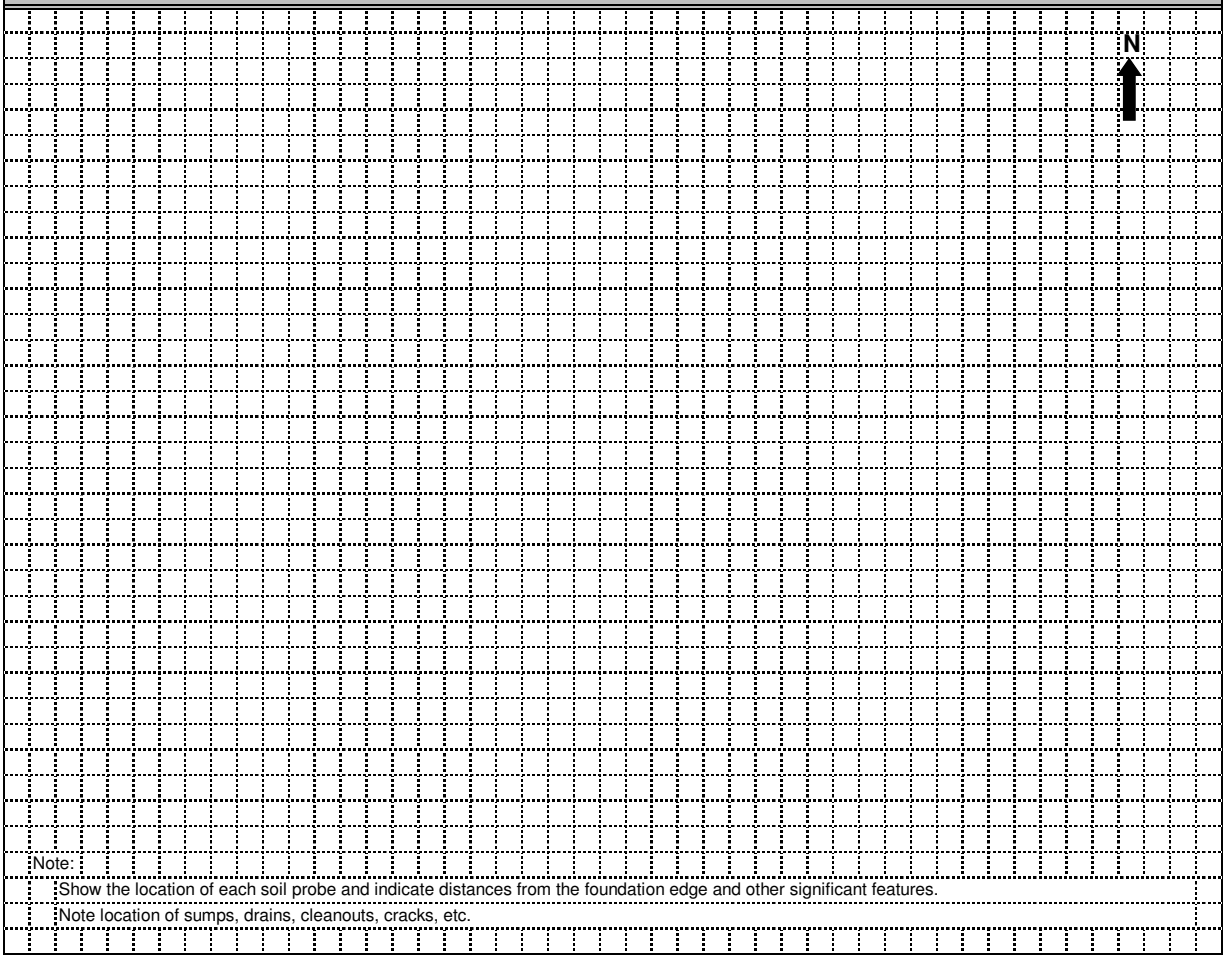
	Sample location (show in diagram)	1	2	3	4
	Sample Identification (field ID)				
Probe Installation	Depth of slab (inches)				
	Depth of hole drilled (inches below slab surface)				
	Depth of installed probe (inches below slab surface)				
Manifold Leak check	Leak check (sampling manifold) - Pass/No Pass				
Probe Purge	Purge rate, mL/min.				
	Purge Start (time of day)				
	Purge vacuum, " Hg				
	Purge completed (time of day)				
Helium Leak Check (optional)	Leak check (Helium) - % or ppmv				
Field Analysis (optional)	Gem 2000 (O2 / CO2 / CH4) - %				
	PID - ppmv				
Canister Sampling	Canister & flow controller ID (if used)				
	Initial Canister Pressure (" Hg)				
	Sampling rate, mL/min				
	Sampling period started (time of day)				
	Sampling vacuum, " Hg				
	Sampling period ended (time of day)				
	Final Canister Pressure (" Hg)				

Observations and Comments: _____

CH2MHILL ***Applied Sciences Group***

Indoor Vapor Intrusion Assessment
Sub-slab Vapor Sampling Field Log

Diagram - Outline of Structure Foundation & Location of Sub-slab Sampling Probes



Note:
Show the location of each soil probe and indicate distances from the foundation edge and other significant features.
Note location of sumps, drains, cleanouts, cracks, etc.

Other observations and comments:

STANDARD OPERATING PROCEDURE

Collection of Subslab Gas Samples Using SUMMA Canisters—Alternate Method

Purpose

This standard operating procedure (SOP) describes the approach for installing subslab soil gas probes and collecting subslab soil gas samples using canisters (for example, SUMMA canisters or equivalent). It includes instructions on probe installation, leak checking, soil gas sampling, and probe abandonment. This procedure should be used in conjunction with project data quality objectives.

Project-specific Considerations

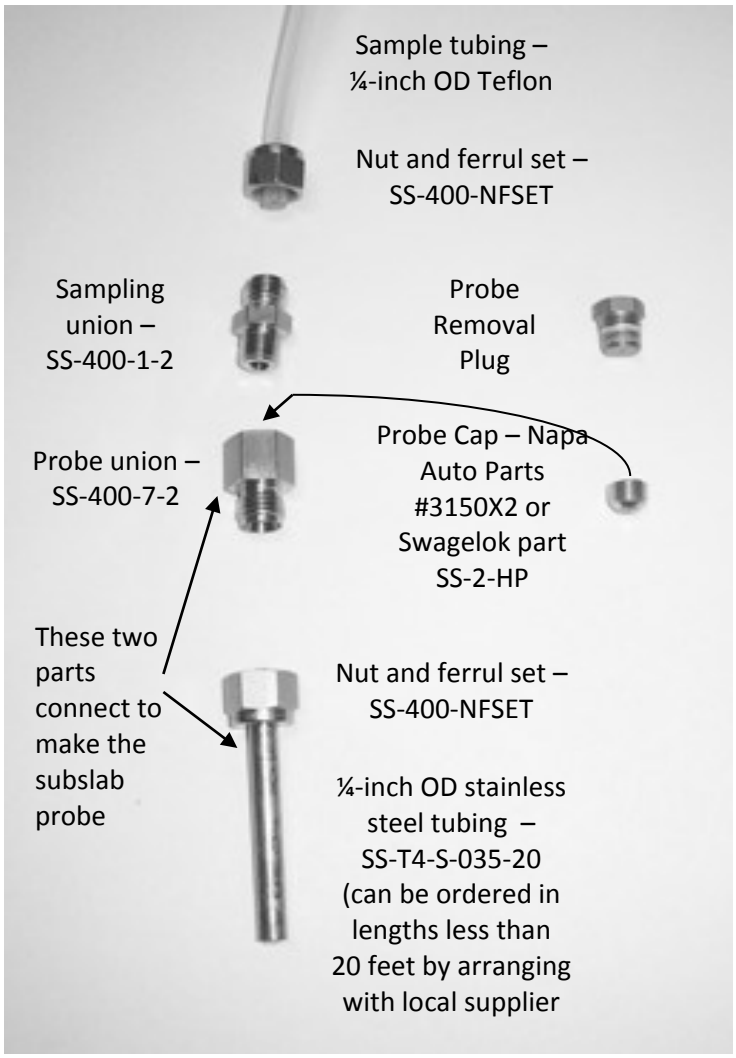
A utility clearance must be performed prior to drilling through the slab, as with all intrusive site work. In addition, it is highly recommended that ground penetrating radar (GPR), specifically a concrete scanner (small, hand-held GPR unit designed for use inside buildings), be used to identify utilities, wire mesh, and/or rebar in the slab prior to drilling. The sampling team should look around the building to locate where utilities come into the building. Utility shutoff valves should be located in case an underground utility is encountered.

Materials

Probe Installation

- Hammer drill and drill bits ($^{7}/_{8}$-inch or 1-inch and $^{5}/_{16}$-inch or ½-inch)
- Vacuum cleaner (shop vac type or handheld) for removing concrete dust from the drilled hole; continuously vacuum the dust as it is generated during the drilling process
- Subslab soil gas probe (for permanent and semi-permanent installations); see Figure 1 for an expanded view of the probe parts
  - ¼-inch outer diameter stainless steel tube (Swagelok part #SS-T4-S-035-20)
  - Swagelok nut and ferrule (part #SS-400-NFSET)
  - Probe union (¼-inch male Swagelok to $^{1}/_{8}$-inch female NPT—part #SS-400-7-2)
  - Probe cap (Napa Auto Parts #3150X2 or Swagelok part #SS-2-HP)
  - Probe seal (flush mounted hex socket plug $^{1}/_{8}$-inch PTFE coated, $^{3}/_{16}$ inch) NPT slotted brass plug) — McMaster-Carr part #4534K11
- Metal tubing cutter for adjusting the length of the probe so that it does not extend below the slab
- Probe seal consisting of Portland cement or Cement-All
- Large cotton swabs or paper towels and non-chlorinated (deionized or distilled) water for cleaning the concrete dust out of the hole
- Tongue depressor, putty knife, or similar tool for putting the probe seal material into the hole
- Teflon pipe tape to wrap the end of the probe tubing so that the probe fits tightly into the hole to prevent the seal material from clogging the probe
- Tape measure to measure the thickness of the slab, measured off of a long screwdriver or drill bit
- Optional: Sonicare toothbrush with bristles removed (this can be useful in removing air bubbles from the cement mixture while installing the probe thus making a more competent seal); toothpicks or Q-tips without cotton tip can also be used for this purpose

FIGURE 1
Probe Parts



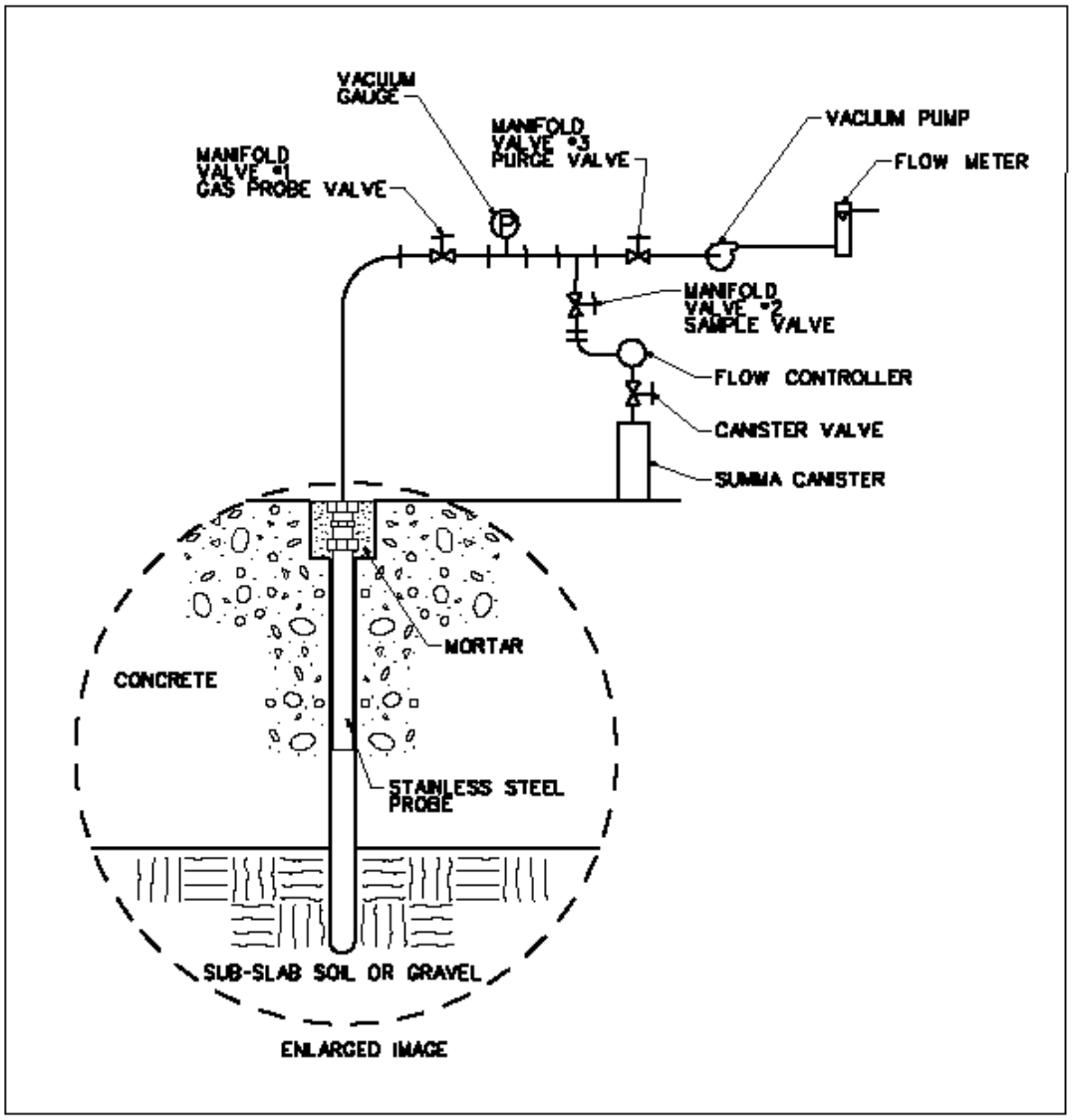
Leak Check

- Helium enclosure (may be constructed from a small bowl or container)
- Helium canister containing high-grade helium (NOT balloon grade) and regulator for the canister (should be set to a flow rate of 200 milliliters per minute [mL/min] or less)
- Helium detector (for example, Dielectric MGD-2002) can be rented from an equipment rental company

Sampling

The subslab soil gas sampling set up is shown in Figure 2.

FIGURE 2
Subslab Sampling



- Sampling union (¼-inch male Swagelok or equivalent to ¼-inch male NPT—part #SS-400-1-2)
- Vacuum pump for purging with rotometer to control flow to 200 mL/min (should be a Cole Parmer # R-79200-00 grey diaphragm pump or equivalent)
- Sampling manifold consisting of Swagelok gas-tight fittings with three valves and one pressure gauge to attach the probe to the air pump and the sample canister; see Figure 10; the manifold must be clean, free of oils, and flushed free of VOCs before use
- Swagelok valve (only necessary for extended sampling periods [for example, 8- or 24-hours] so that the sampling manifold can be disconnected without introducing indoor air into the probe) (part #SS-4P4T)
- Teflon tubing, ¼-inch outer diameter
- Tedlar bag (1-L or 3-L) to collect the purged soil gas, so: (1) it is not discharged into the building, (2) the volume of purged soil gas can be measured, and (3) field screening with a PID or GEM2000 meter can be performed on the purged gas
- Gem2000 Landfill Gas Meter—This is optional if field measurements of CO_2, O_2, CH_4 are necessary

- MiniRae PID Meter—Used for health and safety to ensure breathing zone VOC concentrations remain below levels specified by the health and safety plan; it is also optional to collect field measurements of total VOCs from the probe or purged soil gas; may warn the laboratory if high concentrations are detected so they can dilute the sample before analysis
- Flow controller or critical orifice, certified clean, and set at desired sampling rate—These are typically provided and set by the laboratory. Common sampling rates for subslab soil gas sampling are provided in Table 1.

TABLE 1
Common Sampling Rates for Subslab Soil Gas Sampling

Can Size	Length of Sampling Time	Sampling Flow Rate (mL/min)
6 Liter	1 hour	90
6 Liter	8 hours	11.25
6 Liter	24 hours	3.75
1 Liter	5 minutes	180
1 Liter	1 hour	15
850 mL	5 minutes	150
850 mL	1 hour	12

- Canister, SUMMA polished, certified clean, and evacuated (Canisters are typically provided by the laboratory)
- Miscellaneous fitting (Swagelok nut and ferrule (part #SS-400-NFSET) to connect tubing to sampling union and SUMMA canister
- Negative pressure gauge, oil-free and clean, to check canister pressure. The pressure gauges are typically provided by the laboratory. The laboratory may either provide one pressure gauge to be used with all of the canisters, or a pressure gauge for each canister to be left on during sample collection. Sometimes the canisters are fitted with built-in pressure gauges that are not removable. Gauges sent by the laboratory are for field use only, and are an approximate measure of the actual vacuum. Regularly calibrated—and less rugged—vacuum gauges are used at the laboratory to measure vacuum before shipment and again after sample receipt.

Probe Abandonment

- Probe removal fitting
- Crowbar
- Chisel and hammer
- Concrete patch (either pre-mixed cement patch or Portland cement)

Miscellaneous

- Teflon tape
- Modeling clay (VOC-free) for temporarily sealing probes that are leaking so the probe can be sampled and then patched with cement or Fix-It-All.
- Wrenches and screwdriver (clean and free of contaminants), various sizes as needed for connecting fittings and making adjustment to the flow controller. A $^{9}/_{16}$-inch wrench fits the ¼-inch Swagelok fittings, which most canisters and flow controllers have.
- Extension cord

- Timer/watch
- Tools required to cut carpet, and/or tools needed for removal of other floor coverings
- Shipping container, suitable for protection of canister during shipping; typically, strong cardboard boxes are used for canister shipment; the canisters should be shipped to the laboratory in the same shipping container in which they were received

Subslab Probe Installation

1. Locate the sampling locations in accordance with the work plan. Note the location of the probe, locations of significant features (walls, cracks, sumps, drains, etc.), and conditions of the slab and soil.
2. If needed, expose the concrete by cutting the carpet or other loose floor coverings (Note: Carpet need not be removed, but rather an "L" shape should be cut to expose the concrete for drilling and the leak check enclosure).

FIGURE 3
Drilling 3/8-inch probe hole

3. Drill a $^{7}/_{8}$-inch or 1-inch-diameter hole to a depth of 1¾ inches (measured to the center of the hole) to allow room for installing the probe nut and probe union (see Figures 2 and 3). If the slab is not thick enough to allow installation of the entire length of the probe nut and probe union within the slab, a portion of the probe nut will extend beyond the bottom of the slab. If the probe nut extends beyond the bottom of the slab and into the bedding material, the $^{7}/_{8}$-inch or 1-inch-diameter hole will be drilled through a portion of the bedding material. Remove the cuttings using a vacuum cleaner. Be careful to not compromise the integrity of the slab during drilling (that is, cracking it), although note if this occurs. It is important that the slab and the probe hole remain airtight for sampling and that cracks are noted.
4. Drill a $^{5}/_{16}$-inch or ½-inch-diameter hole through the remainder of the slab and approximately 3 inches down into the subslab material (Figures 2 and 4). If the ¼-inch-diameter stainless steel probe extends into the bedding material, the $^{5}/_{16}$- or ½-inch-diameter hole will be drilled approximately 3 inches beyond the installation depth of the probe to allow for a void that is free of obstructions that might plug the probe during sampling. Record the total depth of the slab and the depth drilled into the subslab material on the attached sampling log.

FIGURE 4
Drilling 1-inch mortar hole to a depth of 1 and 3/4-inch

5. Clean out the drilled hole with the vacuum, cotton swabs, and paper towel. This removes any remaining dust, allowing the seal material to adhere to the hole wall better.
6. Some agencies may require that glass beads be poured into the subslab hole before installing the probe. If so, pour glass "seed beads" (available at a craft store) into the hole until enough beads have been added so that the top of the beads are even with the bottom of the slab. A thin piece of wire marked with the slab thickness and inserted into the hole can be used to determine this.
7. Install the subslab probe into the hole. First, trim the probe to the appropriate length so that when inserted

into the hole it will not extend below the slab. This may not be possible, based on the measured thicknesses of the slabs. The ¼-inch-diameter stainless steel probe will be cut to a sufficient length and wrapped with Teflon tape so that the probe fits tightly into the hole to prevent the seal material from clogging the probe. The probe is constructed of stainless steel tubing and Swagelok parts. Temporary probes consist of ¼-inch OD Teflon tubing.

8. Permanent or semipermanent installations – Wet the walls of the hole using the Q-tip or moistened paper towel. This helps the mortar bond to the drilled concrete. Prepare the mortar in accordance with manufacturer's directions to a stiff consistency. Make sure that the consistency is such that the mixture will not run down the sides of the hole and potentially clog the probe or hole but is still easy enough to work with (so it can be easily scooped into the hole.) Only mix an amount that can be used in 15 minutes. Place sample probe and sample union part way into the hole, as shown in Figure 5. Using the tongue depressor or similar tool, apply mortar around the base of the sampling probe and sampling union such that it will be sealed once it is in place.
9. Fill the hole with mortar, and press the probe further into the hole until its top is flush with the floor. In doing so, slightly wiggle the probe to create good "wetting" contact between the probe and the mortar as well as the mortar and the drilled concrete. It may be helpful to work the concrete with a Sonicare toothbrush (with the bristles removed) or a toothpick or similar object during this step to remove the air bubbles from the mortar and make a more competent seal. Scrape off excess and make sure there is clear access to the probe. See Figure 6.
10. Let dry for 24 hours.
11. Be sure to never leave the probe hole open to atmosphere for extended periods to minimize the effects of surface infiltration. A probe seal or cap should be inserted into the probe union to minimize the effects of surface infiltration while the sealant is drying/curing.

FIGURE 5
Installing probe with mortar

FIGURE 6
Installed probe, flush with slab

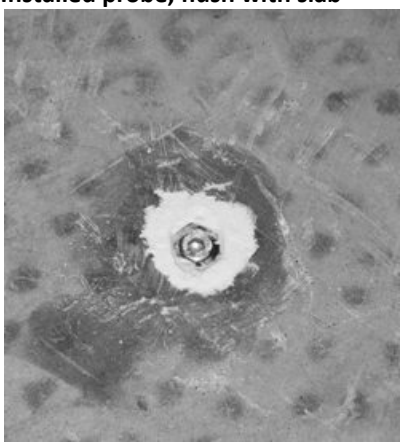
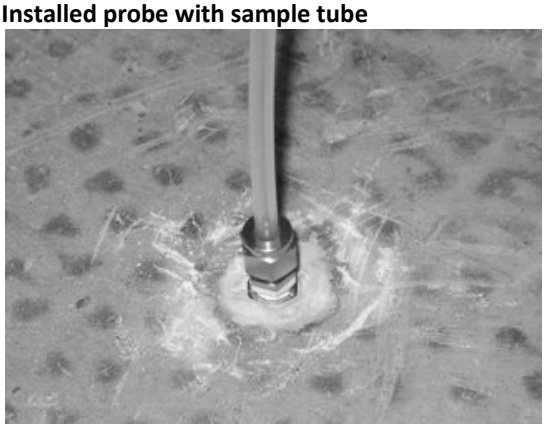


FIGURE 7
Installed probe with sample tube



System Setup

1. Remove the probe seal and attach the sampling union to the subslab probe. Then, attach ¼-inch Teflon tubing to the sampling union with a Swagelok nut and ferrule set. See Figure 7.
2. Place the helium leak check enclosure over the subslab probe by threading the Teflon tubing through the hole of the enclosure. Slide the enclosure down so it seals on the concrete slab. If there is an uneven surface (for example, carpet and concrete), modeling clay can be used to seal the bottom of the helium enclosure to the ground surface. Attach the other end of the sample tube to the sampling manifold with the use of a nut and ferrule set. See Figures 8 to 10.

FIGURE 8
Installing the helium leak check assembly

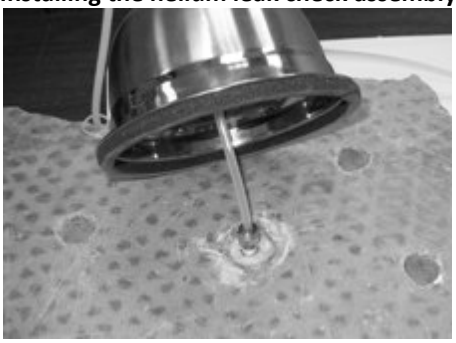
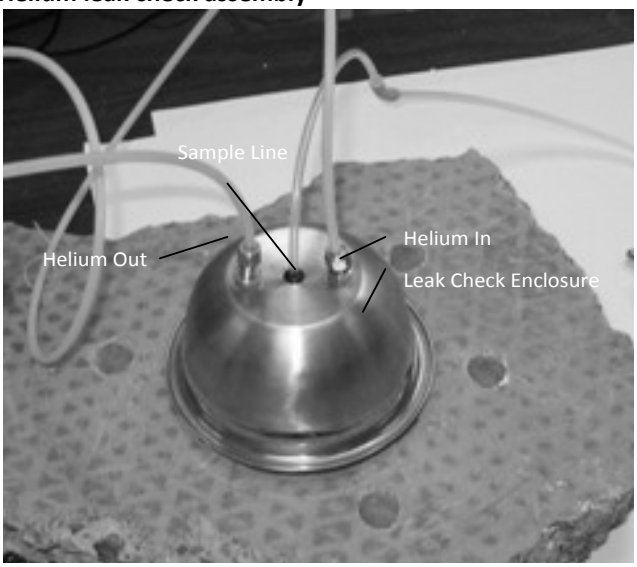


FIGURE 9
Helium leak check assembly



3. Attach the subslab sample tubing to the sampling manifold. See Figure 10. ***Do not connect the canister at this time***.
4. If the sample will be collected over a period of time greater than 30 minutes a flow diversion valve (Swagelok part #SS-4P4T) should be placed in-line between the probe and the manifold. Once purging has been completed, the flow diversion valve can be turned to the off position, allowing disconnection of the manifold and vacuum pump for use at another location, without the loss of purge integrity at the purged location.
5. Adjust the vacuum pump to achieve the desired flow rate of 200 mL/min. This should be performed at the outlet of the vacuum pump before purging, either by using a suitable flow meter or calculating the amount of time required to fill a 1-liter Tedlar bag.
6. Attach the air pump to the sampling manifold and the Tedlar bag to the air pump exhaust.

FIGURE 10
Sampling Manifold

System Leak Checking and Purging

1. Physical Leak Check—Perform a leak check of the sample manifold system by doing the following (Figure 10):

    A. Make sure the gas probe valve (valve #1) is closed and the sample valve (valve #2) is open.

    B. Open the purge valve (valve #3) and start the vacuum pump. Verify that the flow is set to 200 mL/min.

    C. Close the sample valve (valve #2) and achieve a vacuum gauge reading of 10 inches of mercury (Hg) or to a vacuum that will be encountered during sampling, whichever is greater.

    D. A leak-free system will be evident by closing off the purge valve (valve #3), turning off the vacuum pump, and observing no loss of vacuum within the sampling manifold system for a period of 30 seconds. Repair any leaks prior to sample collection by tightening the fittings on the manifold. Re-test to make the sure the manifold passes the physical leak check before proceeding.

    E. Record the leak check date and time on the field sampling log.

2. System Purge and Helium Leak Check—A purge of the subslab probe and sampling manifold system is required. The helium leak check procedure is also performed during this step. The leak check will verify the integrity of the probe seal. This is accomplished by doing the following:

    A. Place the helium leak check enclosure around the subslab probe to achieve a buildup of helium in the leak check enclosure. The enclosure should not be tightly sealed and there should be an exhaust for the helium so pressure doesn't build up in the enclosure.

    B. Start the flow of helium to the leak check enclosure at 200 mL/min. Try to position the tube so the helium is directed at the interface between the probe and the ground. Let the helium fill the enclosure for 1 minute.

    C. Open the sample valve (valve #2) and the purge valve (valve #3) and start the purge pump. Verify that the flow rate is still 200 mL/min.

D. Open the sample valve (valve #2) and the purge valve (valve #3) and start the purge pump. Verify that the flow rate is still 200 mL/min.

E. To start the soil gas probe purge, simultaneously open the gas probe valve (valve #1) and close the sample valve (valve #2), and start timing. It is important to switch these two valves simultaneously. Otherwise, a vacuum can be built up in the sampling system, and its sudden release can draw concrete powder (left at the bottom of the probe hole after drilling) into the sampling system, which will damage the valves and vacuum pump.

F. If there is shallow groundwater in the area, carefully watch the tubing as the pump is turned on. If water is observed in the sample tubing, shut the pump off immediately. Subslab soil gas collection will not be feasible if the probe is in contact with water.

G. Connect the helium detector to the enclosure exhaust to confirm that helium is present in the enclosure during purging. It is optional to measure the helium concentration within the enclosure. Make sure that the helium detector is exposed to ambient air and "zeros out" before measuring the purged soil gas.

H. Purge the first 30 seconds (approx. 100 mL) into a 1-liter Tedlar bag. Remove the bag and replace with a fresh 1-L Tedlar bag. Continue the purge for at least another 2.5 minutes. This will result in a total of about 500 mL of purge gas in the second bag and 600 mL of purge volume total. At the end of the purge time, remove the Tedlar bag from the pump and connect it to the helium detector. The helium concentration in the purged soil gas must be less than 1 percent of what it was in the helium enclosure during purging to pass the leak test (10,000 parts per million by volume [ppmv] if the helium concentration was 100 percent) (verify that this limit is consistent with appropriate project-specific regulatory guidance). Either: (1) calculate what 1 percent of the helium concentration was in the enclosure from the measured concentration in Step 7.2.6; or (2) use a limit of 0.1 percent (1,000 ppmv), which allows for a 10-times safety margin. If the probe fails the leak check then corrective action is required.

I. There are three corrective action options:

   i. Make sure that all the fittings are tight and add Teflon tape to them.

   ii. Try fortifying the probe seal by adding more sealing material or modeling clay and repeating the purge and leak check procedure.

   iii. If the above two options fail, abandon the hole, drill a new one, and repeat the whole procedure.

   Note: **Helium leak detectors may be sensitive to high concentrations of methane or other atmospheric gasses.** If these are expected to be present in the subslab soil gas, then caution should be used with this technique, as false positive readings may be encountered during leak testing. Use a GEM2000 landfill gas meter to determine if methane is present in subslab soil gas.

J. If the vacuum gauge reads greater than 7 in Hg during the purge, then close the purge valve (valve #3) and monitor the vacuum in the manifold and probe. If there is no noticeable change in vacuum after a minute, then there is an insufficient amount of soil gas to collect a sample and the vacuum is too great to collect a soil gas sample. Several factors can cause this situation. Consult with the project manager and take corrective action.

   i. The soil formation is too "tight" (that is, high clay or moisture content). Try using a lower flow rate.

   ii. If water is visible in the flexible soil gas tubing, stop the purging immediately. It is not possible to take a soil gas sample at that depth or location.

K. At the end of the calculated purge time and after the system is verified to be leak free, close the purge valve (valve #3), close the valve to the Tedlar bag, and turn off the pump. Do not open the purge valve again. Doing so will result in loss of the purge integrity and will require re-purging. Remove the Tedlar bag and turn off the helium leak detector.

L. The purged subslab soil gas in the Tedlar bag can be screened with a GEM2000 landfill gas meter to get field measurements of CO_2, O_2, and CH_4 and/or a MiniRae PID can be used to measure concentrations of total VOCs in the field.

M. Record the purge date, time, purge rate, leak check result, and purge volume on the field sampling log.

N. Immediately move on to the sampling phase. Little to no delay should occur between purging and sampling.

Sample Collection

1. "Clean" sampling protocols must be followed when handling and collecting samples. This requires care in the shipping, storage, and use of sampling equipment. The cleanliness of personnel who come in contact with the sampling equipment is also important, so smoking, eating, drinking, perfumes, deodorants, and dry-cleaned clothing are prohibited. Canisters should not be transported in vehicles with gas-powered equipment or gasoline cans. Sharpie markers should not be used for labeling or note-taking during sampling.
2. The air sampling canisters are certified clean and evacuated by the laboratory to about 29 to 30 inches Hg vacuum. Initial canister vacuums that are less than certified by the laboratory are a potential indication of leakage that could affect the accuracy of analytical results. Care should be used at all times to prevent inadvertent loss of canister vacuum. Never open the canister's valve unless the intent is to collect a sample or check the canister vacuum with an attached gauge.
3. Verify that the vacuum pressure of the canister is between 28 to 30 inches mercury (Hg). Do not use a canister that has an initial pressure less than 28 inches Hg because that canister likely leaked during shipment. Measure the initial canister vacuum using an external vacuum gauge, as described:

   A. Remove the protective cap from the canister; make sure the canister valve is closed before doing this.

   B. Attach an external vacuum gauge to the canister and open the valve. If the vacuum gauge has two openings, make sure that the other opening is closed; the canister cap can be used for this. After taking the reading, record the initial vacuum, close the canister valve and remove the gauge.

   C. Measure the initial canister pressure using a digital vacuum gauge with 0.25 percent accuracy at the -30 to 0 inches Hg range and NIST-traceable calibration for vacuum measurements. See the *Technical Bulletin: Use of External Vacuum Gauges with Canisters* for a recommended model of vacuum gauge[1] for use with Summa canisters used for vapor intrusion sampling.

   D. Do not sample using a canister without sufficient initial vacuum. Be advised that sampling data may be flagged or rejected from canisters with low initial vacuum (less than 28 inches Hg). Low initial vacuum could create a low bias in analytical results due to air leakage. While there is also a smaller risk that air leakage could introduce contaminants into the canister, the primary concern is the low bias to analytical results; this bias is within the range of analytical variability allowed with USEPA Method TO-15 (± 30 percent) for initial vacuums greater than 24 inches Hg. The following table identifies the field team's response based on the initial vacuum reading for a canister. In addition, this table also identifies the potential bias to results at different initial canister vacuums.

[1] A PG5 Digital Pressure Gauge from Automation Products Group (APG), Inc.(http://www.apgsensors.com/products/pressure-sensors/digital-pressure-gauges/pg5) with National Institute of Standards and Technology (NIST)-traceable calibration certificate, or equivalent, is recommended for making vacuum measurements.

E. Use the following table to determine when to use canisters based on initial vacuum readings.

Initial Vacuum Reading	Potential Error in Analytical Results Due to Leakage	Field Team Response
Greater than 30 to 28 inches Hg	Up to -10% error	Use canister for sampling –no limitations on use.
Greater than 26 to 28 inches Hg	Up to -21% error	Use canister for sampling if necessary; replace canister with a spare if spares are available.
Greater than 24 to 26 inches Hg	Up to -30% error	Sampling with canister is not advisable. Contact project manager and obtain direction before sampling with this canister. Be advised that qualifiers may be applied to analytical results sampled with canisters with vacuums less than 26 inches Hg.
Less than 24 inches Hg	Greater than-30% error	Do not use this canister for sampling. Analytical results will be rejected.

4. Attach the canister to the flow controller and then connect the flow controller to the sample valve (valve #2) on the sampling manifold. Open the sample valve (valve #2)
5. Before taking the sample, confirm that the sampling system valves are set as follows:
   - The purge valve (valve #3) is confirmed to be closed, gas probe valve (valve #1) is open
   - The sample valve is (valve #2) is open.
6. Slowly open the canister's valve approximately one full turn.
7. After sampling for the appropriate amount of time (determined from the work plan; see Table 1), close the sample valve (valve #2) and the canister's valve. If the canister has a built-in or assigned pressure gauge, allow the canister to fill until the vacuum pressure reaches 2 to 10 inches Hg for 6-liter canisters and 2 to 5 inches Hg for 1-liter canisters. Check the sample canister before the durations shown in Table 1 to ensure that the canister does not reach atmospheric pressure. Remove the canister from the sampling manifold.
   - If sampling for extended periods of time (for example, 8 or 24 hours), check the samples at some point several hours before the expected completion time (for example, at 18 or 20 hours for a 24-hour sample) to make sure the canister is collecting at the expected rate. It may also be a good idea to check the canister several hours into the sampling period (for example, 2 or 4 hours for a 24-hour sample). The flow controllers are rarely set to the exact sampling period.
8. If using an external vacuum gauge, re-attach it, open the canister valve, and record the final pressure. Close the valve, remove the gauge, and replace and tighten the cap on the canister. Ideal final vacuum pressure in the canister is between 2 and 10 inches Hg (6 L) or 2 and 5 inches Hg (1 L). More than 10 (5) inches Hg can greatly increase reporting limits; however, a small amount of vacuum pressure should be left in the canister so the laboratory can confirm that the canister was not opened during shipment.
9. Consult with the project manager before submitting the sample to the laboratory if a final vacuum greater than 10 inches Hg, or less than 2 inches Hg are encountered. Use the following table for guidance to determine how to address final vacuum measurements.

Final Vacuum Reading	Field Team Response
Less than 2 inches Hg	Contact Project Manager before submitting sample. Notify analytical laboratory to report their laboratory-measured pressure and to get direction from the project manager before analyzing sample.
Greater than 2 inches Hg and less than 10 inches Hg	Submit sample for analysis - no limitations on data use
Greater than 10 inches Hg	Contact project manager before submitting sample. Verify final vacuum with the analytical laboratory before analysis.

10. Canisters with no vacuum left (that is, 0 inches Hg) should not be analyzed. Contact the project manager before submitting a sample with a final vacuum of 0 inch Hg to determine the appropriate course of action. One option is to verify the final vacuum with the analytical laboratory. If there is vacuum remaining in the canister according to the laboratory vacuum gauge, the project manager may direct the analytical laboratory to analyze the sample.
11. The analytical laboratory should be directed to not analyze a sample showing a final vacuum of 0 inch Hg (as measured by the laboratory), and to notify the project manager and obtain further guidance regarding that sample.
12. If the flow controller is going to be used for more than one sample collection, be sure to purge it between uses. To do this, attach the flow controller to a vacuum source and draw clean air or gas (ultra-high purity) through it for several minutes before attaching it to the canister.
13. Record the sampling date, time, canister identification (ID), flow controller ID, and any other observation pertinent to the sampling event on the attached Sampling Log. Also record the weather conditions (temperature, barometric pressure, precipitation, etc.) during sampling.
14. Fill out all appropriate documentation (sampling forms, sample labels, chain of custody, sample tags, etc.).
15. Disassemble the sampling system.
16. For permanent probes, replace the probe cap and make sure it is securely in place.
17. Evacuate the Tedlar bags. Be sure this is done outside.

Sample Handling and Shipping

1. Fill out all appropriate documentation (chain of custody, sample tags) and return canisters and equipment to the laboratory.
2. The canisters should be shipped back to the laboratory in the same shipping container in which they were received. The samples do not need to be cooled during shipment. DO NOT put ice in the shipping container.
3. When packing the canisters for shipment, verify that the valve (just past finger tight) and valve caps are snug (¼ turn past finger-tight), and use sufficient clean packing to prevent the valves from rubbing against any hard surfaces. Never pack the cans with other objects or materials that could cause them to be punctured or damaged.
4. **Do not place sticky labels or tape on any surface of the canister.**
5. Place a custody seal over the openings to the shipping container.
6. Make sure to insure the package for the value of the sample containers and flow controllers if corporate card policy does not cover this.
7. Ship canisters for overnight delivery.

Probe Advancement and Removal

1. After sampling, it is critical that the probe either be removed or plugged to prevent the creation of a new pathway for vapor intrusion.
2. If the probe is to be used again in the future, wrap the probe seal insert with Teflon tape and tighten it into the probe opening, using a hex key, until it is tight and flush with the concrete floor.
3. If the probe is to be removed, insert the removal fitting into the probe. Using a crow bar, remove the entire probe assembly. If this does not work, use a hammer and chisel to remove the concrete and loosen the probe. If the probe cannot be removed in this manner, then over drill the probe with a rotary hammer drill and 1-inch drill bit.
4. Fill the hole with Portland cement mix and return the surface as near to pre-sampling conditions as possible.

Quality Control

1. Canister supplied by the laboratory must follow the performance criteria and quality assurance prescribed in USEPA Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking.
2. Flow controllers supplied by the laboratory must follow the performance criteria and quality assurance prescribed in USEPA Method TO-14/15 for flow controller cleaning and adjustment.

Attachment

- Subslab Soil Gas Sampling Log—Canister Method

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Indoor Vapor Intrusion Assessment
Sub-slab Vapor Field Sampling Log - Summa Canister Method

Project Info

Project Name: _____ **Project # :** _____

By: _____ **Date:** _____

Structure

Identification: _____

Address: _____

Slab Information:

☐ Concrete slab on grade (directly on top of soil) ☐ Other (describe) _____

☐ Concrete slab on gravel underlayment _____

Condition of slab _____

Type of Sub Slab Soil _____

Is water present in the soil _____

Sub-slab Probe Installation, Leak Checking, Probe Purging, & Sampling Log

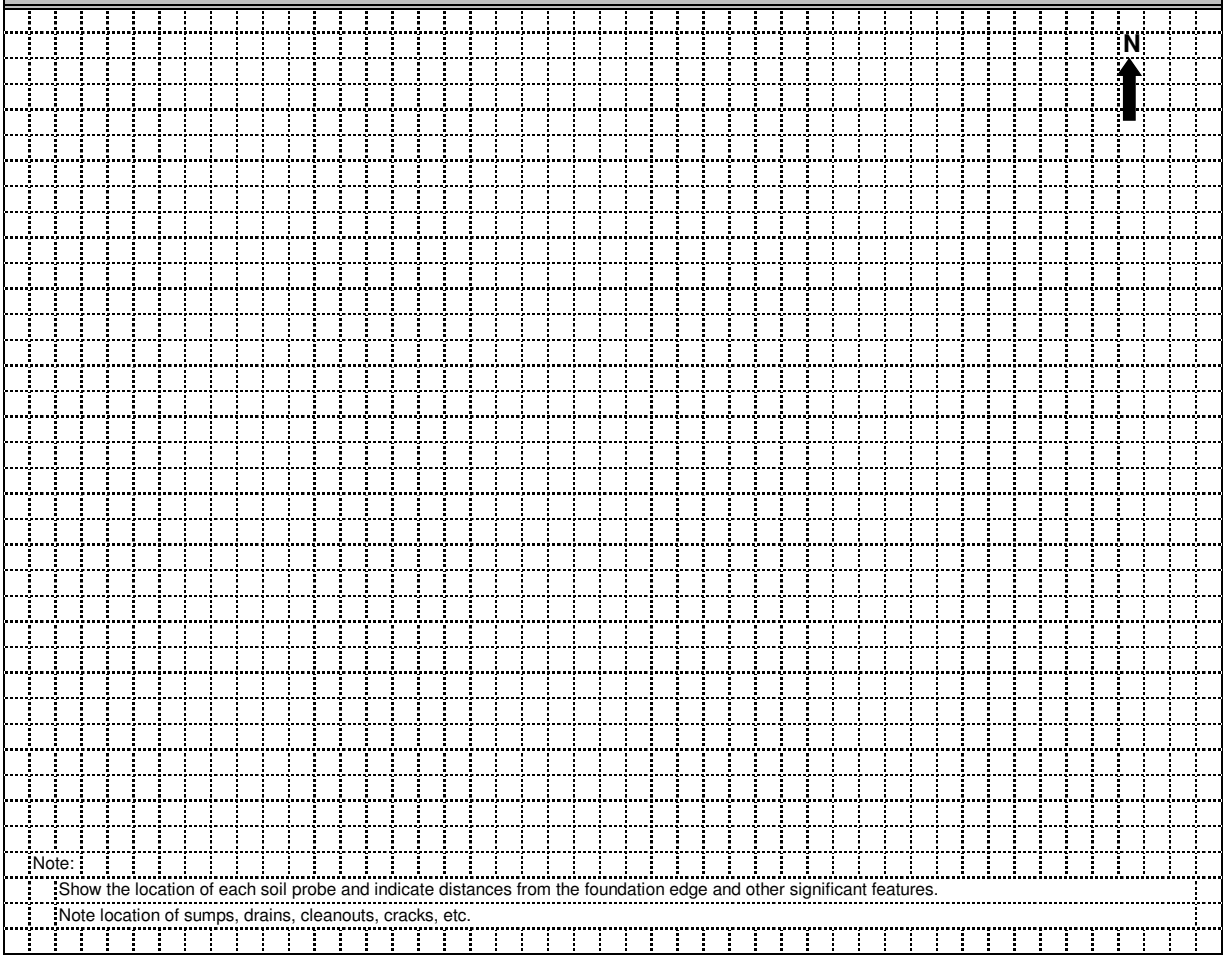
	Sample location (show in diagram)	1	2	3	4
	Sample Identification (field ID)				
Probe Installation	Depth of slab (inches)				
	Depth of hole drilled (inches below slab surface)				
	Depth of installed probe (inches below slab surface)				
Manifold Leak check	Leak check (sampling manifold) - Pass/No Pass				
Probe Purge	Purge rate, mL/min.				
	Purge Start (time of day)				
	Purge vacuum, " Hg				
	Purge completed (time of day)				
Helium Leak Check (optional)	Leak check (Helium) - % or ppmv				
Field Analysis (optional)	Gem 2000 (O2 / CO2 / CH4) - %				
	PID - ppmv				
Canister Sampling	Canister & flow controller ID (if used)				
	Initial Canister Pressure (" Hg)				
	Sampling rate, mL/min				
	Sampling period started (time of day)				
	Sampling vacuum, " Hg				
	Sampling period ended (time of day)				
	Final Canister Pressure (" Hg)				

Observations and Comments: _____

CH2MHILL ***Applied Sciences Group***

Indoor Vapor Intrusion Assessment
Sub-slab Vapor Sampling Field Log

Diagram - Outline of Structure Foundation & Location of Sub-slab Sampling Probes



Note:
Show the location of each soil probe and indicate distances from the foundation edge and other significant features.
Note location of sumps, drains, cleanouts, cracks, etc.

Other observations and comments:

STANDARD OPERATING PROCEDURE

Integrated Ambient Indoor, Outdoor, and Crawl Space Air Sampling Method for Trace VOCs Using SUMMA Canisters

Scope and Application

This standard operating procedure (SOP) describes the procedure for collecting ambient air samples for targeted volatile organic compounds (VOCs). Reporting limits for these samples are usually very low and extremely prone to positive bias from interfering VOC sources. The method presented here is based on "clean" sampling techniques. The requirements of clean sampling dictate that sampling and sample handling are done by trained personnel. A building survey must be performed before sample collection. It is the responsibility of the project team to make sure this procedure meets all applicable regulatory standards and receives approval/concurrence from the leading regulatory agency for the project.

Summary of Method

A sample of air is withdrawn, using clean technique, into a certified clean and evacuated SUMMA canister using a certified-clean flow controller. Sample collection can be integrated over time by adjusting the flow controller. Project-specific sample periods as short as 10 minutes to as long as 24 hours can be achieved based on the size of canister used and the sampling rate selected (see Table 1). Generally, six-liter canisters are used for ambient air sampling. In cases where the crawl space is most conveniently sampled by access through crawl space vents, a sampling probe (sample delivery line made of Teflon or stainless steel) of sufficient length is attached to the inlet of the flow controller.

Apparatus and Materials

- Canister, SUMMA-polished, certified-clean, and evacuated. (Canisters are typically provided by the laboratory.)
- Flow controller, certified clean and set at desired sampling rate. (Flow controllers are typically provided and set by the laboratory.)
- Shipping container suitable for protection of canister during shipping. Typically, strong cardboard boxes are used for canister shipment. The canisters should be shipped back to the laboratory in the same shipping container in which they were received.
- Wrenches and screw driver (clean and free of contaminants), various sizes as needed for connecting fittings and making adjustment to the flow controller. A $^{9}/_{16}$-inch wrench fits the ¼-inch Swagelok fittings, which most canisters and flow controllers have.
- Negative pressure gauge, oil-free and clean, to check canister pressure. (The pressure gauges are typically provided by the laboratory.) The laboratory may provide either one pressure gauge to be used with all of the canisters, or a pressure gauge for each canister to be left on during sample collection. Sometimes the canisters are fitted with built-in pressure gauges that are not removable.
- Sampling probe, new Teflon or stainless steel tubing, fitted with compression fittings. (For crawl space samples.)
- Sampling cane or similar device for outdoor air sampling to prevent water from entering canister during sampling.

Sample Location Selection

Indoor, outdoor, and crawl space air sample locations should be selected during the building survey and in consultation with the building owner/occupant. The sample locations should be selected to meet the project-specific data quality objectives.

Guidelines for Selecting Indoor Air Sample Locations

1. Typically, indoor air samples should be collected from each compartment or heating, air-conditioning, and ventilation (HVAC) zone within a building.
2. Typically, indoor air samples should be collected on the lowest floor of the building at breathing zone height (approximately 3 to 5 feet) toward the center of the building away from windows.
3. Consideration should be given on a case-specific basis to those situations (such as a day care facility) where a different sampling height may also be appropriate to evaluate a unique setting or population.
4. Indoor air samples should be located in the areas of the building that are occupied most frequently and by the most amount of people.
5. Indoor air samples can be collected from more than one floor within a structure to address varying risk exposures and as part of the process to distinguish contaminants related to vapor intrusion from background sources. Thus, the location and position of the sample container will vary depending on which floor the sampling event takes place.
6. The basement sample(s) are primarily designed to investigate worst-case situations within a structure. Therefore, basement samples are positioned as close as possible to the source area (for example, sumps or major cracks in the foundation).

Guidelines for Selecting Outdoor Air Sample Locations

1. Typically, outdoor air samples are collected upwind and/or downwind of the building or site being investigated.
2. Avoid biasing the sample results by placing the canister near potential outdoor VOC sources such as busy roads or gas stations.
3. Outdoor air samples are typically located at least 10 feet away from buildings. However, the outdoor air canister may be placed near the outdoor air intake for the HVAC system for the building.
4. Outdoor air sample canisters should be secured to an immovable structure to ensure security for sampling in public areas. A bicycle lock or piece of chain and padlock can be used. NOTE: Do not secure the canister to or close to a living tree; however, because the tree's evapotranspiration process may release VOCs from groundwater into the vicinity. It may be a good idea to attach a label to the canister explaining that it is an environmental sample and should not be tampered with. The label can also include contact information.
5. Typically, outdoor air samples should be collected at breathing zone height (approximately 3 to 5 feet).

Guidelines for Selecting Crawl Space Air Sample Locations

1. Crawl space air samples are typically collected in locations selected to achieve adequate spatial coverage of the building's crawl space. Sample location selection will be limited by accessibility.
2. Crawl space air sample inlets should be located several feet from the opening or access point to avoid dilution by outdoor air. In cases where the crawl space is most conveniently sampled by access through crawl space vents, a sampling probe (sample delivery line made of Teflon or stainless steel) of sufficient length is attached to the inlet of the flow controller.

Sampling Schedule

Sample collection should ideally occur during typical operating conditions (that is, if workers occupy the building from 8 a.m. to 4 p.m., the sample collection would also take place from 8 a.m. to 4 p.m.). However, building owners/occupants may request that sampling take place when the building is not in use. In this case, make sure the HVAC system is set to typical operating conditions. Also, consider when the sample pressure will need to be checked (for example, it is not a good idea to start 24-hour samples at 8 a.m. because they will need to be checked around 4 a.m. the next day).

Sample Collection

1. "Clean" sampling protocols must be followed when handling and collecting samples. This requires care in the shipping, storage, and use of sampling equipment. Cleanliness of personnel who come in contact with the sampling equipment is also important: no smoking, eating, drinking, perfumes, deodorants, dry cleaned clothing, etc. Canisters should not be transported in vehicles with gas-powered equipment or gasoline cans. Sharpie markers should not be used for labeling or note-taking during sampling.
2. The SUMMA canisters are certified clean and evacuated by the laboratory to near absolute zero pressure. Care should be used at all times to prevent inadvertent loss of canister vacuum. ***Never open the canister's valve unless the intent is to collect a sample or check the canister pressure.***
3. Prior to taking indoor air samples, be sure to complete an indoor air building survey (see the vapor intrusion SOP, *Conducting Building Surveys for Vapor Intrusion Evaluations*). When taking outdoor or crawl space air samples, be sure to note on the field log any items that might bias analytical results (such as gasoline cans, garbage, fresh paint, etc.)
4. Inspect the canister for damage and do not use a canister that has visible damage. The field team should order some additional canisters in case these are needed to replace visibly damaged canisters or canisters that have leaked during initial leak testing.
5. Verify that the vacuum pressure of the canister is between 28 to 30 inches mercury (Hg). Do not use a canister that has an initial pressure less than 28 inches Hg because that canister likely leaked during shipment. Measure the initial canister vacuum using an external vacuum gauge, as follows:
   A. Remove the protective cap from the canister; first, make sure the canister valve is closed.
   B. Attach an external vacuum gauge to the canister and open the valve. If the vacuum gauge has two openings, make sure that the other opening is closed; the canister cap can be used for this. After taking the reading, record the initial vacuum, close the canister valve and remove the gauge.
   C. Measure the initial canister pressure using a digital vacuum gauge with 0.25 percent accuracy at the -30 to 0 inches Hg range and NIST-traceable calibration for vacuum measurements. See the *Technical Bulletin: Use of External Vacuum Gauges with Canisters* for a recommended model of vacuum gauge[1] for use with Summa canisters used for vapor intrusion sampling.
   D. Do not sample using a canister without sufficient initial vacuum. Be advised that sampling data may be flagged or rejected from canisters with low initial vacuum (less than 28 inches Hg). Low initial vacuum could create a low bias in analytical results due to air leakage. While there is a also a smaller risk that air leakage could introduce contaminants into the canister, the primary concern is the low bias to analytical results; this bias is within the range of analytical variability allowed with the USEPA Method TO-15 (± 30 percent) for initial vacuums greater than 24 inches Hg. The following table

[1] A PG5 Digital Pressure Gauge from Automation Products Group (APG), Inc. (http://www.apgsensors.com/products/pressure-sensors/digital-pressure-gauges/pg5) with National Institute of Standards and Technology (NIST)-traceable calibration certificate, or equivalent, is recommended for making vacuum measurements.

identifies the field team's response based on the initial vacuum reading for a canister. In addition, the table also identifies the potential bias to results at different initial canister vacuums.

E. Use the following table to determine when to use canisters based on initial vacuum readings.

Initial Vacuum Reading	Potential Error in Analytical Results Due to Leakage	Field Team Response
Greater than 30 to 28 inches Hg	Up to -10% error	Use canister for sampling –no limitations on use.
Greater than 26 to 28 inches Hg	Up to -21% error	Use canister for sampling if necessary; replace canister with a spare if spares are available.
Greater than 24 to 26 inches Hg	Up to -30% error	Sampling with canister is not advisable. Contact project manager and obtain direction before sampling with this canister. Be advised that qualifiers may be applied to analytical results sampled with canisters with vacuums less than 26 inches Hg.
Less than 24 inches Hg	Greater than -30% error	Do not use this canister for sampling. Analytical results will be rejected.

2. Flow controllers (if used) should come preset by the laboratory to sample at a pre-determined rate based on specific project requirements (see Table 1 for the most common options). In some cases (that is, project-specific quality assurance [QA]), the flow rate will need to be verified in the field prior to use. This is accomplished with a bubble meter, vacuum source, and instructions supplied by the laboratory.
3. In the field log record the canister identification (ID), flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort. The indoor and outdoor temperature and barometric pressure should be recorded when sampling begins and is completed.
4. Connect the flow controller to the canister.
    A. The flow controller fitting denoted "LP" or "OUT" is connected to the canister. Tighten the fitting to be leak free but do not over-tighten (a ¼ turn past snug is usually enough.) When tightening the fitting, be sure that the valve assembly does not rotate by using your other hand to hold the valve steady.
    B. If an assigned pressure gauge is used for each canister, the pressure gauge should be attached to the canister first and then the flow controller should be attached to the pressure gauge.
    C. When the flow controller and pressure gauge are attached correctly they will not move separately from the canister (they will not spin around).
5. For outdoor samples, be sure that the inlet to the flow controller is protected from precipitation. Either place the canister and flow controller under a shelter/enclosure, use a sampling cane provided by the laboratory or use a clean piece of aluminum foil to build a tent over the flow controller inlet.
6. If crawl spaces are being sampled remotely through a crawl space vent, adjust the length of the sampling probe to achieve the desired sampling location and place an inert spacer (wire clothes hanger) near the end of the probe to keep the probe tip opening suspended about 3 inches above the ground level. Then, connect the sampling probe to the inlet of the flow controller.
7. Remove all work articles from the sampling area.
8. To begin sampling, slowly open the canister valve one full turn.

9. For canisters with built-in or assigned pressure gauges, monitor the vacuum pressure change several times during the course of the selected sample period to ensure the canister is filling at the desired rate.
10. At the end of the sample period, close the canister valve finger-tight.
11. Remove the flow controller (and assigned pressure gauge) and replace the protective cap on the canister valve fitting.
12. Measure the final canister vacuum with the digital vacuum gauge. Attach the digital vacuum gauge, open the canister valve, and record the final vacuum. Close the valve, remove the gauge, and replace and tighten the cap on the canister.
13. Ideal final vacuum in the canister is between 2 and 10 inches Hg. More than 10 inches Hg means that a smaller than expected sample volume has been collected, which can increase reporting limits. A small amount of vacuum should be left in the canister to assess the potential for leakage during transport to the laboratory.
14. Consult with the project manager before submitting the sample to the laboratory if a final vacuum greater than 10 inches Hg, or less than 2 inches Hg are encountered. Use the following table for guidance to determine how to address final vacuum measurements:

Final Vacuum Reading	Field Team Response
Less than 2 inches Hg	Contact project manager before submitting sample. Notify analytical laboratory to report their laboratory-measured pressure and to get direction from the project manager before analyzing sample.
Greater than 2 inches Hg and less than 10 inches Hg	Submit sample for analysis—no limitations on data use.
Greater than 10 inches Hg	Contact project manager before submitting sample. Verify final vacuum with the analytical laboratory before analysis.

15. Canisters with no vacuum left (that is, 0 inches Hg) should not be analyzed. Contact the project manager before submitting a sample with a final vacuum of 0 inch Hg to determine the appropriate course of action. One option is to verify the final vacuum with the analytical laboratory. If there is vacuum remaining in the canister according to the laboratory vacuum gauge, the project manager may direct the analytical laboratory to analyze the sample.
16. The analytical laboratory should be directed to not analyze a sample showing a final vacuum of 0 inch Hg (as measured by the laboratory), and to notify the project manager and obtain further guidance regarding that sample.
17. If the flow controller is going to be used for more than one sample collection, be sure to purge it between uses. To do this, attach the flow controller to a vacuum source and draw clean air or gas (ultra-high purity) through it for several minutes before attaching it to the canister.

Sample Handling and Shipping

1. Fill out all appropriate documentation (chain of custody, sample tags) and return canisters and equipment to the laboratory.
2. The canisters should be shipped back to the laboratory in the same shipping container in which they were received. The samples do not need to be cooled during shipment. DO NOT put ice in the shipping container.

3. When packing the canisters for shipment, verify that the valve (just past finger tight) and valve caps are snug (¼ turn past finger-tight), and use sufficient clean packing to prevent the valves from rubbing against any hard surfaces. Never pack the cans with other objects or materials that could cause them to be punctured or damaged.
4. **Do not place sticky labels or tape on any surface of the canister!**
5. Place a custody seal over the openings to the shipping container.
6. Make sure to insure the package for the value of the sample containers and flow controllers if corporate card policy does not cover this.
7. Ship canisters for overnight delivery.

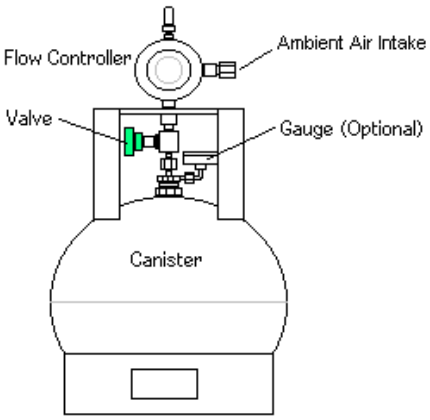
Quality Control

1. Canisters supplied by the laboratory must follow the performance criteria and quality assurance prescribed in USEPA Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking. SOPs are required.
2. Flow controllers supplied by the laboratory must follow the performance criteria and QA prescribed in USEPA Method TO-14/15 for flow controller cleaning and adjustment. SOPs are required.

TABLE 1
Common Sampling Rates for Ambient Air Sampling

Can Size	Length of Sampling Time	Sampling Flow Rate (ml/min)
6 Liter	1 hour	90
6 Liter	8 hours	11.25
6 Liter	24 hours	3.75
1 Liter	5 minutes	180
1 Liter	1 hour	15
850 mL	5 minutes	150
850 mL	1 hour	12

FIGURE 1
Assembled Canister Sampler for Integrated Sample Collection



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Vapor Intrusion Best Practices

Indoor, Outdoor, and Crawl Space Air Sampling Log - Canister Method

Project Information

Project Name: ..... Project # : .....

Sampler Name: ..... Date: .....

Sampling Data Log

Sample Location	Field ID	Canister ID	Flow Controller ID	Initial Canister Pressure ("Hg)	Initial Flow Controller Rate (ml/min)	Start Date & Time	End Date & Time	Final Pressure ("Hg)	Final Flow Controller Rate (ml/min)

Sample Location Diagram

N

Note:

Draw in outline the structure's foundation and interior walls, identify rooms, and note other defining features. Show location of canister relative to physical objects, etc.

Weather conditions and indoor temperature: .....

.....

.....

Other Observations and Comments (note any unique circumstances): .....

.....

.....

QC and Reviewed 8/2011

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Vapor Intrusion Best Practices

Indoor, Outdoor, Crawl Space Air Sampling Log - Canister Method

Field ID	Bldg #	Location Description	Canister ID	Pressure Gauge ID	Flow Controller ID	Flow Controller Rate	Sample Start Date	Sample Start Time	Initial Canister Pressure ("Hg)	20-hr Check Time	20-hr Check Pressure ("Hg)	Sample End Date	Sample End Time	Final Pressure ("Hg)	Indoor Temp (^{o}F)	Outdoor weather conditions
field duplicate																

QC and Reviewed 8/2011

STANDARD OPERATING PROCEDURE

Organic Vapor Monitor

Purpose and Scope

The purpose of this standard operating procedure (SOP) is to provide guidelines for the calibration and use of an organic vapor monitor (OVM). This is a broad guideline for field use of an OVM; for specific instruction, refer to the operations manual.

Equipment and Materials

- Operations manual
- An OVM hand-readout unit and side pack assembly
- 100 parts per million (ppm) isobutylene as calibration gas
- T-type feeder tube with 1.5 liter per minute regulator

Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THE OVM. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

1. Introduction—The OVM is designed to detect organic materials in air. It uses a photoionization detector as its detection principle. The detector allows the monitor to respond to a wide variety of organic compounds.
2. Operational Checks—See basic operating instructions in the operations manual.
3. Calibration—See basic operating instructions in the operations manual.
4. Soil Organic Vapor Monitoring
   - Place a 2- to 4-inch soil core immediately into a sealable plastic bag upon opening the core barrel or direct-push technology (DPT) liner and seal the bag.
   - If readings will not be collected immediately, record the soil sample depth on the outside of the plastic bag using a marker.
   - Slightly open the plastic bag and insert the monitor's sensor.
   - Record the OVM reading on the soil boring log at the correct depth interval.

Key Checks and Preventive Maintenance

- Check battery.
- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use.

A complete preventive maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual. The following are some key issues:

- A complete spare instrument should be available whenever field operations require volatiles monitoring.
- Spare parts should be on hand so minor repairs may be made in the field.
- Batteries should be charged daily.
- Occasionally allow the batteries to totally discharge before recharging.

Attachment B
Calibration Log

Instrument Calibration Log

Project Name/Number:

Field Personnel:

Make, Model and Serial Number of Unit:

Date:

Time	Calibration Gas/Solution	Concentration of Calibration Gas/Solution	Calibration Gas Lot Number	Expiration Date	Calibrated Instrument Reading	Comments	Initial

Make, Model and Serial Number of Unit:							
Date:							
Time	Calibration Gas/Solution	Concentration of Calibration Gas/Solution	Calibration Gas Lot Number	Expiration Date	Calibrated Instrument Reading	Comments	Initial

Make, Model and Serial Number of Unit:							
Date:							
Time	Calibration Gas/Solution	Concentration of Calibration Gas/Solution	Calibration Gas Lot Number	Expiration Date	Calibrated Instrument Reading	Comments	Initial

Appendix D
Site Safety and Health Plan

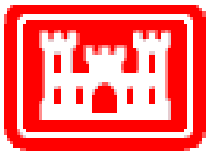
Final Accident Prevention Plan

RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant Former Hanley Area St. Louis, Missouri

Contract No. W912DQ-11-D-3005 Task Order 0009

Prepared for



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December 2013

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Contents

Appendix

Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AHA	Activity Hazard Analysis
APP	Accident Prevention Plan
COR	Contracting Officer's Representative
CPR	cardiopulmonary resuscitation
CSHO	Corporate Safety and Health Officer
EAP	Employee Assistance Program
EMR	Experience Modification Rate
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manager
IARC	International Agency for Research on Cancer
IDW	investigation-derived waste
IIPP	Injury and Illness Prevention Program
MSDS	Material safety data sheet
OSHA	U.S. Occupational Safety and Health Administration
PPE	personal protective equipment
PM	Project Manager
PTSP	Pre-Task Safety Planning
RI	remedial investigation
SSC	Site Safety Coordinator (equivalent to site safety and health officer)
SSHP	Site Safety and Health Plan
USACE	U.S. Army Corps of Engineers

1. Signature Page

Accident Prevention Plan
St. Louis Ordnance Plant, Former Hanley Area
St. Louis, Missouri

Date November 2012

Plan Preparer:

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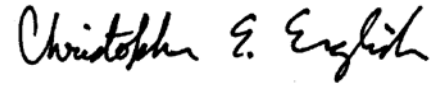

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2. Background Information

This Accident Prevention Plan (APP) has been developed to protect and guide the personnel conducting a remedial investigation (RI). The site covered in this investigation consists of the St. Louis Ordnance Plant, former Hanley Area, and properties located offsite. This APP has been prepared to meet applicable requirements of the U.S. Army Corps of Engineers (USACE) Safety and Health Requirements Manual EM 385-1-1 (USACE 2008); the *Code of Federal Regulations* (CFR), 29 CFR 1910.1200 Hazard Communication Standard; Hazardous Waste Operations or emergency response as required by 29 CFR 1910.120 and 29 CFR 1926.65; and the corporate safety and health policies of CH2M HILL, Inc. Various portions of this work shall also be conducted under the Nonhazardous Waste site protocols. The Site Safety and Health Plan (SSHP) for this project is included as Appendix A of this APP.

2.1 Contractor

CH2M HILL, Inc.

2.2 Contract Number

W912DQ-11-D-3005, Task Order 0009

2.3 Project Name

Remedial Investigation/Feasibility Study of Operable Unit 2 at the St. Louis Ordnance Plant, Former Hanley Area

2.4 Project Description and Location

This APP presents the hazards known or anticipated to be present at the St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri. Tasks included under this APP will be conducted at the former Hanley Area and at various properties near the site. The area included in the RI is bound to the north by Henner Avenue, to the east by Goodfellow Boulevard, to the south by the former Hanley Area and Stratford Avenue, and to the west by Irving Drive. The former Hanley Area will be used to contain support material and will serve as a staging area during the RI. This plan also outlines the health and safety procedures that will be used to conduct the RI. The sampling is expected to begin in 2013. This APP will be used by CH2M HILL and its subcontractors to identify and mitigate task-specific hazards and to select appropriate health and safety protective measures.

Onsite personnel must review the APP and sign an agreement to comply with its provisions prior to commencing onsite work. The APP and attached SSHP are considered operational documents that are subject to revisions in response to various site-specific conditions that may be encountered. However, these documents may be modified or updated only with the approval of the Health and Safety Manager (HSM) and Project Manager (PM).

Specific work activities requiring activity hazard analyses (AHAs) are listed in Section 2.6.

2.5 Contractor Accident Experience

CH2M HILL's exceptional safety performance greatly exceeds the industry average. Our injury and illness rates and our Experience Modification Rate (EMR) have decreased over the past 5 years.

The following information and Table 2-1 provide examples of our achievements:

- An EMR of less than 1.0 over the past 5 years, which is the average accident injury experience for the industry, with a 2011 EMR of 0.67 (or 67 percent) of the industry average (North American Industry Classification System Code 54133).

TABLE 2-1
CH2M HILL's Safety Performance

Category	2007	2008	2009	2010	2011
Employee Hours	13,744,013	15,290,819	14,673,402	12,842,086	10,704,063
EMR	0.74	0.66	0.72	0.71	0.67
Fatalities	0	0	0	0	0
Recordable Incidents	27	48	20	8	13
Recordable Incident Rate *	0.39	0.63	0.27	0.12	0.24
Recordable Incident Rate Average *	1.4	1.4	1.1	1.2	1.0
Lost Workday Incidents (DART) **	7	11	3	0	3
Lost Workday Incident Rate (DART)	0.10	0.14	0.04	0.00	0.12

Notes:
* North American Industry Classification System code 54133 (Engineering Services) used for rate averages.

** Lost Workday incidents include cases involving days away from work or Restricted Duty. This is also known as DART (days away, restricted, or transferred cases).

2.6 Work Requiring Activity Hazard Analysis

The planned field tasks requiring AHAs are as follows.

- Task 01: Building surveys and chemical inventories
- Task 02: Subslab soil gas, indoor and outdoor air sampling
- Task 03: Monitoring well installation
- Task 04: Groundwater sampling
- Task 05: Investigation-derived waste (IDW) management

AHAs for each of these field tasks are included in Appendix A.

3. Statement of Safety and Health Policy and Compliance Procedures

CH2M HILL is committed to providing a safe and healthful workplace for employees. These conditions will be ensured through an aggressive and comprehensive worker safety and health program that is integrated with other site worker protection activities. We regard employee protection as a priority and are committed to developing, implementing, and improving safety and health practices that will afford optimal protection to employees and enable continuous improvement of the quality of worker protection performance. The safety and health of employees will take precedence whenever conflicts with production or other objectives arise.

Managers and supervisors are held accountable for worker safety and health. Accountability is achieved by assigning worker protection responsibilities, evaluating personnel performance, and holding personnel accountable for worker protection performance.

In addition to complying with this APP and their corporate safety and health program, persons working under the SSHP are encouraged to be active participants in their workplace safety and health activities, and to actively take advantage of the worker rights in a responsible manner, without reprisal.

The following activities may result in disciplinary action, up to and including discharge of any employee from their corporation:

- Violation of the safety and health requirements of their corporation's policy or of this APP
- Unauthorized or illegal possession, use, or sale of alcohol or controlled substances on work premises, during working hours, while engaged in corporate activities, or in corporate vehicles
- Use or sale of firearms or explosives on work premises

See Appendix A, Section 1.0, for additional details.

4. Responsibilities and Lines of Authorities

This section identifies the personnel who have specific safety responsibilities on the project.

4.1 Personnel with Safety Responsibilities

Participating personnel are responsible for complying with safety procedures and for proactively making safety awareness part of their day-to-day conduct.

The following positions have specific corporate and project safety responsibilities:

- HSM
- Corporate Safety and Health Officer (CSHO)
- PM
- Site Safety Coordinator (SSC)
- Other project field staff

The SSHP (Appendix A) lists the specific personnel that will fill the stated positions for this project. Lines of authority are detailed in Appendix A, Section 4.

All work is conducted under a Behavior Based and Loss Prevention System program. AHAs are a vital part of this work, as well as using Pre-task Safety Planning (PTSP). All staff are accountable for their own health and safety, and have the authority to request a work stoppage when they feel unsafe behaviors, actions, or situations are occurring.

All work requiring a competent person per U.S. Occupational Safety and Health Administration (OSHA) definition (29 CFR 1926.32(f)), will not be started until that competent person is designated and onsite. *Competent person* means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Details are provided in Appendix A, beginning with Section 8.4.

5. Subcontractors and Suppliers

Subcontractors and suppliers providing services onsite will be subject to the safety provisions of this APP and those included in Appendix A. See Section 5.0 of Appendix A for details. **At this time, CH2M HILL plans to use four subcontractors to fulfill this task order.**

This APP has been constructed to directly track with the EM 385-1-1 2008 Appendix A, “Minimum Basic Outline for Accident Prevention Plan.”

CH2M HILL and any identified subcontractors shall conduct site work in accordance with this APP and associated documents. CH2M HILL shall address compliance with specific safety and health requirements, including those listed in Section 9, through safety meetings at the start of each shift. The specific safety and health requirements and site conditions will be reviewed with field personnel during these meetings. All parties shall also comply with the requirements of their respective Injury and Illness Prevention Programs (IIPPs).

6. Training

Site workers, supervisors, and managers will have training appropriate to their assigned duties and as specified in the SSHP and AHAs that are applicable to the work being performed. As specified in Section 4.0 of Appendix A, the SSC (who will also conduct the project safety and health inspections), will meet the training and indoctrination requirements prescribed in this APP and Appendix A, as well as the Hazardous Waste Operations and Emergency Response (HAZWOPER) supervisory training. All employees engaging in hazardous waste operations or emergency response shall receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65. At a minimum, the training shall have consisted of instruction in the topics outlined in 29 CFR 1910.120 and 29 CFR 1926.65. As there are tasks planned that require a competent person, competent-person-level training is not required. Personnel who have not met these training requirements shall not be allowed to engage in hazardous waste operations or emergency response activities.

Details of required training are specified in Section 6.0 of Appendix A.

7. Safety and Health Inspections

7.1 Inspection Details

The project SSC (specifically identified in the attached SSHP) will provide onsite safety and health inspections for this project. The SSC will meet the training and indoctrination requirements as prescribed in this APP and Appendix A, including HAZWOPER supervisory training, cardiopulmonary resuscitation (CPR), first-aid, and bloodborne pathogen awareness training. The SSC will also have hands-on experience overseeing these types of tasks.

See Section 7.0 of Appendix A for further inspection details.

7.2 Recordkeeping

Project safety and health documentation will be maintained by the CSHOs for the respective companies. Records to be maintained (both in project files of each of the respective companies, and in the onsite field trailer) will include:

- HAZWOPER training certificates
- First aid and CPR training certificates
- Documentation of medical surveillance.
- Daily safety and health briefing acknowledgment forms
- Deficiency identification, correction, and follow-up documentation
- Accident reports and investigation records
- Respirator usage and fit training, as applicable
- Material safety data sheets (MSDSs) for sample preservatives

7.3 External Inspection/Certifications

External inspections or certifications will not be required for this work.

8. Accident Reporting

The SSC will prepare monthly reports in accordance with Paragraph 01.D.05 (c) of the EM 385-1-1, which accurately reflects the employee-hours worked each month for all site workers, both prime and subcontractor. The monthly report will be prepared on the form provided by the Contracting Officer's Representative (COR) and attached to the monthly billing request submitted to the COR.

The SSC and HSM are responsible for all incidents reporting. Specific details are found in Section 9.0 of Appendix A.

Also, all significant accidents shall be reported as soon as possible, but not more than 24 hours afterwards to the COR. The contractor shall thoroughly investigate the incident and submit the findings of the investigation along with appropriate corrective actions to the Contracting Officer/COR in the prescribed format as soon as possible, but no later than 5 working days following the incident. Implement corrective actions as soon as reasonably possible.

The following occurrences require immediate accident notification:

- A fatal injury
- A permanent total disability
- A permanent partial disability
- The hospitalization of three or more people resulting from a single occurrence
- Property damage of $200,000 or more

9. Plans Required By the EM 385-1-1 Safety Manual

Plans required by the EM 385-1-1 Safety Manual are presented in the following sections. Plans and procedures that are not applicable to this project are indicated as such with the nonapplicability rationale.

9.1 Layout Plan

The site layout will be provided prior to start of work.

9.2 Emergency Response Plans

Details are provided in Section 12.1 of Appendix A. Medical support for this project will be provided onsite and offsite. These plans fulfill the following requirements:

- Procedures and tests
- Security/asset protection plan
- Spill plans
- Posting of emergency telephone numbers
- Medical support

9.2.1 Onsite Medical Support

When two or more field staff are present onsite, at least two will have current certification in basic first-aid and CPR, along with bloodborne pathogens annual training. Unless injured, the SSC will be the lead person to initiate any required first-aid until offsite medical support can be engaged.

9.2.2 Offsite Medical Support

In the event of a medical emergency or if follow up to basic first-aid is required, request emergency medical transport as opposed to transporting the injured person in a private or company vehicle where practical. The contact and location information for the nearest offsite medical support is presented below. A map indicating the travel route to the nearest medical facility with emergency care is presented in the SSHP.

Medical facility:
Barnes-Jewish Hospital South
One Barnes-Jewish Hospital Plaza
St. Louis, Missouri 63110
Phone #: (314) 747-3000
Emergency #: 911

9.2.3 Hospital Addresses and Route

Information on the nearest medical facility with emergency care is discussed in the front portion of Appendix A.

Further specific details are provided in Section 12.0 of Appendix A.

9.3 Alcohol and Drug Abuse Prevention

In order to maintain a drug and alcohol free workplace, the respective parties have established a drug and alcohol free awareness program to educate employees on the following: (1) the danger of drug abuse and alcohol in the workplace; (2) the corporate drug and alcohol free workplace policy; (3) the availability of any drug and alcohol counseling, rehabilitation, and employee assistance programs; and (4) the penalties that may be imposed upon employees for drug abuse and alcohol violations, and violations of the corporation's drug and alcohol free workplace. Such education includes the distribution of the drug- and alcohol-free workplace

policy at the employment interview; a discussion of the drug- and alcohol-free workplace policy at the new employee orientation session; and inclusion of the company's drug- and alcohol-free workplace policy in the employee handbook and any other personnel policy publications.

9.3.1 CH2M HILL

The corporation has vital interests in ensuring a safe, healthy, and efficient working environment for our employees, our subcontractors, and the clients we serve. The unlawful or improper use of controlled substances or alcohol in the workplace presents a danger to everyone. In addition, as a federal contractor we have a duty to comply with the requirement of the Drug-Free Workplace Act of 1988. For these reasons, the following drug- and alcohol-abuse policies apply to CH2M HILL employees as a condition of employment and continued employment with the corporation:

> *Employees are prohibited from reporting to work or working while using illegal or unauthorized substances. Employees are prohibited from reporting to work or working when the employee uses any drugs, except when the use is pursuant to a doctor's orders and the doctor has advised the employee that the substance does not adversely affect the employee's ability to safely perform his or her job duties. This does not include the authorized use of alcohol at corporate-sponsored functions or activities.*
>
> *In addition, employees are prohibited from engaging in the unlawful or unauthorized manufacture, distribution, sale, or possession of illegal or unauthorized substances and alcohol in the workplace including on client paid time, on client premises, in client vehicles, or while engaged in client activities.*
>
> *In accordance with the Drug-Free Workplace Act of 1988, employees must notify their supervisor of any criminal drug statute conviction for a violation occurring within the workplace within 5 days of such conviction.*
>
> *Employment with the corporation is conditioned upon an employee's full compliance with the foregoing drug and alcohol free workplace policy. Any violation of this policy may result in disciplinary action, up to and including discharge. Furthermore, any employee who violates this policy who is subject to termination may be permitted in lieu of termination, at the corporation's sole discretion, to participate in and successfully complete an appropriate treatment, counseling, or rehabilitation program as recommended by a substance abuse professional as a condition of continued employment and in accordance with applicable federal, state, and local laws.*
>
> *Consistent with its fair employment policy, the corporation maintains a policy of nondiscrimination and reasonable accommodation with respect to recovering addicts and alcoholics, and those having a medical history reflecting treatment for substance abuse conditions. We encourage employees to seek assistance before their drug and alcohol use renders them unable to perform their essential job functions or jeopardizes the health and safety of themselves or others. The corporation will attempt to assist its employees through referrals to rehabilitation, appropriate leaves of absence, and other measures consistent with the corporation's policies and applicable federal, state, or local laws.*
>
> *The corporation further reserves the right to take any and all appropriate and lawful actions necessary to enforce this drug and alcohol free workplace policy including, but not limited to, the inspection of corporation-issued lockers, desks, or other suspected areas of concealment. Employees are required to submit for "post accident" and "for cause" drug and alcohol screening following any incident. Random drug and/or alcohol screening is not a requirement of CH2M HILL unless required by a client.*

9.3.2 Employee Assistance Program

Employees may participate in CH2M HILL's Employee Assistance Program (EAP) immediately upon hire. The EAP helps eligible employees and their immediate families with a wide range of problems, including marriage and family problems; emotional problems; alcoholism and alcohol abuse; drug abuse and dependency; financial problems; compulsive gambling; and eating disorders. Employee conversations and records under the EAP are strictly confidential. The administrative cost of this program is fully paid by the company.

9.4 Site Sanitation Plan (Section 02)

The following subsections constitute the Site Sanitation Plan for this project.

9.4.1 Drinking Water

A cooler containing an adequate supply of drinking water will be available at the site for the site workers and replenished each day. The cooler will be stored outside the exclusion zone on or near the field vehicles.

9.4.2 Toilets

Because of the short duration of field activities, no toilets will be provided onsite. Restroom facilities are located at nearby gas stations and/or restaurants.

9.4.3 Washing Facilities

Access to washing facilities is available at the same location as the restroom facilities.

9.4.4 Food Service

No food service will be provided onsite. Site workers either will bring their food to the site to be consumed outside of the exclusion zone and only after proper decontamination, or will go offsite for food.

9.4.5 Waste Disposal

Any IDW will be stored, profiled, and disposed of in accordance with the project work plan.

Nonhazardous waste materials and rubbish will be contained in a garbage bag and disposed of with regular site sanitary service disposal or at an offsite disposal facility.

9.4.6 Vermin Control

No enclosed spaces are being constructed for this project and waste materials will be securely stored and transported offsite to provide vermin control.

9.5 Access and Haul Road Plan (Section 04.B)

NOT APPLICABLE. No access or haul roads are being constructed for this work.

9.6 Respiratory Protection Plan (Section 05.G)

Not required.

9.7 Health Hazard Control Plan (Section 06.A)

Safety and health hazards for performing work covered under this APP are identified through the preparation of AHAs (provided in Appendix A). Each AHA also indicates recommended controls for each identified potential safety/health hazard.

Appropriate personal protective equipment (PPE) shall be supplied and used at all times for this project. PPE selection is based on the selected hazard control measures specified in the AHAs (Section 12.6 of Appendix A).

9.8 Hazard Communication Program

Chemical products may occasionally be stored and used on the project site, and/or stored on field vehicles. Examples of chemicals include gases used to calibrate sensing equipment. Other chemicals may be used as

well. These chemicals may pose hazards including flammability, corrosiveness, reactivity and incompatibility, and toxicity. Because of the potential hazards, special precautions must be taken, including the following:

- Tracking and controlling hazardous chemical products received and stored.
- A hazard evaluation of each chemical product, using such sources as MSDSs.
- Informing workers of the potential hazards through training, MSDSs, and appropriate labeling of containers.
- Air monitoring in the case of potential respiratory hazards.
- Design and implementation of engineering controls such as ventilation and source control.
- Developing storage, handling, housekeeping, and decontamination procedures.
- Assigning appropriate PPE, such as eye and face protection, gloves, body protection, and respirators. Respirator usage by CH2M HILL or subcontractor employees will be in accordance with the employees' IIPP.
- Training personnel handling chemicals on safe handling procedures, personal protective equipment, and emergency and spill cleanup procedures.

Hazardous substances that may be encountered in soil on the project site are not covered by this program. Appendix A addresses chemical and other hazard assessment and mitigation associated with site contaminants including investigation and remediation of waste materials.

9.8.1 Chemicals Covered by this Project Program

For the purposes of this program, chemicals considered to be hazardous are those:

- Listed in the OSHA Permissible Exposure Limits.
- Included in the American Conference of Governmental Industrial Hygienists (ACGIH) *Threshold Limit Values for Chemical Substances* (2007).
- Found to be suspected or confirmed carcinogens by the National Toxicology Program in the latest edition of the Annual Report on Carcinogens, or by the International Agency for Research on Cancer (IARC) in the latest edition of the IARC monographs.

No chemicals are expected to be used during field activities as part of this scope of work.

Exceptions to this policy, by OSHA definition, include consumer products that are used in a consumer fashion and pose no more of an exposure hazard than a consumer would face.

9.8.2 Training

Employees who work with or are potentially exposed to hazardous chemicals will receive initial training on the elements of the Hazard Communication Program, including the following:

- Content and requirements of the program and the OSHA Hazard Communication Standard
- The potential physical and toxic hazards of the chemicals used in their work location, and especially the hazards of nonroutine tasks
- Chemical inventory and tracking procedures
- Location of the Hazard Communication Program, the chemical inventory, and the MSDSs
- How to read MSDSs
- Methods to detect the release of or exposure to chemicals in their area
- Content and interpretation of labels

- Safe use and handling of chemicals
- Required personal protective equipment
- Basic emergency procedures

Additional training will be provided on an annual basis, whenever a new chemical is added to the workplace, and when nonroutine tasks are planned.

9.8.3 Labeling

The SSC will ensure that hazardous chemicals brought onto the site are properly labeled with at least the following information, in English, as a minimum, and the language of non-English-speaking employees who may use the product, as appropriate. This labeling includes the following:

- Identity of the product and chemical components
- Appropriate hazard warnings
- Name and address of the manufacturer, importer, or other responsible party

Hazard warnings will also be transmitted in the form of the National Fire Prevention Agency or Hazardous Materials Information System color-coded warnings, which are ranked on a 0 to 4 scale. When chemicals are transferred to a portable container, labels containing chemical identification and hazard warnings must be affixed to the portable container.

9.8.4 Current Onsite Inventory

NOT APPLICABLE.

9.9 Process Safety Management Plan

NOT APPLICABLE. This work does not include chemical management.

9.10 Lead Abatement Plan

NOT APPLICABLE. Lead is not known to be an exposure concern for this project.

9.11 Asbestos Hazard Control Plan

NOT APPLICABLE. Asbestos is not known to be an exposure concern for this project.

9.12 Radiation Safety Program

NOT APPLICABLE. Radiation hazards not anticipated for this work.

9.13 Abrasive Blasting

NOT APPLICABLE. This work does not involve abrasive blasting.

9.14 Heat/Cold Stress Monitoring Plan

See Sections 13.2.4 and 13.2.5 of Appendix A.

9.15 Crystalline Silica Monitoring Plan

NOT APPLICABLE. Crystalline silica is not known to be an exposure concern for this project.

9.16 Night Operations Lighting Plan

NOT APPLICABLE. Work will not be conducted at night.

9.17 Fire Prevention Plan

See Section 12.9 of Appendix A for more details.

9.18 Wildland Fire Management Plan

NOT APPLICABLE. Wildland fires are not anticipated as a risk for this work.

9.19 Hazardous Energy Control Plan

NOT APPLICABLE. Servicing or maintenance on a system where the unexpected energizing, startup, or release of kinetic or stored energy that could cause injury or damage to occur is not part of this project.

9.20 Critical Lift Procedures

NOT APPLICABLE. No critical lifts will be performed under this scope of work.

9.21 Contingency Plan for Severe Weather

NOT APPLICABLE. Development of a severe weather contingency plan is related to marine operations and therefore does not apply to this scope of work. However, exterior fieldwork on this project will be suspended in the event of severe weather that could impact field activities. Such work suspension will be communicated immediately to the PM.

9.22 Float Plan

NOT APPLICABLE. This work is not over water or requiring use of a boat.

9.23 Fall Protection Plan

NOT APPLICABLE. This work does not require elevated areas.

9.24 Demolition Plan (Engineering and Asbestos Surveys)

NOT APPLICABLE. This work does not involve demolition.

9.25 Excavation/Trenching Plan

NOT APPLICABLE. This work does not require excavation or trenching

9.26 Emergency Rescue (Tunneling)

NOT APPLICABLE. Tunneling and other underground construction is not necessary for this work.

9.27 Underground Construction Fire Prevention and Protection Plan

NOT APPLICABLE. This work does not occur underground.

9.28 Compressed Air Plan

NOT APPLICABLE. Compressed air usage is not necessary for this work, except for calibration gases of very small amounts.

9.29 Formwork and Shoring Erection and Removal Plans

NOT APPLICABLE. This work does not involve forming or shoring.

9.30 Precast Concrete Plan

NOT APPLICABLE. Work does not involve precast concrete.

9.31 Jacking Plan (Lift) Slab Plans

NOT APPLICABLE. These plans are associated with concrete masonry work, which is not part of this project.

9.32 Steel Erection Plan

NOT APPLICABLE. This work does not involve steel erection.

9.33 Site Safety and Health Plan

An SSHP is attached to this APP as Appendix A. The SSHP meets the requirements for work on hazardous waste sites in accordance with 29 CFR 1910.120 and 29 CFR 1926.65.

Detailed site-specific hazards and controls are provided in Appendix A and the AHAs.

9.34 Blasting Plan

NOT APPLICABLE. This work does not involve blasting.

9.35 Diving Plan

NOT APPLICABLE. This work does not involve diving.

9.36 Confined Space

CSE will be performed as part of air sampling request within the underground tunnel system. This will be performed by a subcontractor to CH2M HILL in accordance with 29CFR1910.146 and ANSI Z117.1 in addition to EM385-1-1 and CH2M HILL SOP.

10. Risk Management Processes

The specific processes are addressed in multiple sections of Appendix A, depending on whether classified as physical, chemical, or other type (see Sections 12 through 15), as well as the task-specific AHAs included in Appendix A.

Appendix A
Site Safety and Health Plan

Site-specific Health and Safety Plan—
Revision 0

RI/FS Activities for Operable Unit 2 (Vapor Intrusion Pathway)

St. Louis Ordnance Plant
Former Hanley Area
St. Louis, Missouri

Contract No. W912DQ-11-D-3005 Task Order 0009

Prepared for

Department of the Army

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December 2013

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Contents

Attachments

Figure

Tables

Acronyms and Abbreviations

AHA	activity hazard analysis
ANSI	American National Standards Institute
APP	Accident Prevention Plan
BBLPS	Behavior Based Loss Prevention System
BG	Business Group
CIH	certified industrial hygienist
CFR	*Code of Federal Regulations*
CO	carbon monoxide
COC	contaminant of concern
CHSO	Compliance Safety and Health Officer
COR	Contracting Officer's Representative
CPR	cardiopulmonary resuscitation
CRZ	contamination reduction zone
CSIR	Contractor Safety Incident Report
CSP	Certified Safety Professional
dBA	decibel(s) (A-weighted scale)
DOT	Department of Transportation
ECC	environmental compliance coordinator
EM	environmental manager
ERP	Emergency Response Plan
°F	degrees Fahrenheit
FS	feasibility study
GFCI	ground fault circuit interrupter
HAZCOM	Hazard Communication
HAZWOPER	Hazardous Waste Operations and Emergency Response
HITS	Hours and Incident Tracking System
HS&E	Health, Safety, and Environment
HSE&Q	health, safety, environment, and quality
HSM	health and safety manager
IDLH	immediately dangerous to life and health
IDW	investigation-derived waste
IRF	Incident Report Form
kV	kilovolt

lpm	liter per minute
LPO	Loss Prevention Observation
MSDS	Material Safety Data Sheet
NCS	non-permit confined space
NLI	Loss and Near Loss Investigation
NSC	National Safety Council
OSHA	Occupational Safety and Health Administration
OU	operable unit
PCE	tetrachloroethene
PEL	Permissible Exposure Limit established by OSHA
PID	photo ionization detector
PIP	photoionization potential
PM	project manager
PPE	personal protective equipment
ppm	part(s) per million
PRCS	permit-required confined space
PTSP	Pre-task Safety Planning
QCSM	Quality Control Systems Manager
REM	Responsible Environmental Manager
RCA	Root Cause Analysis
REL	recommended exposure limit
RHSM	responsible health and safety manager
RI	remedial investigation
RMSF	Rocky Mountain spotted fever
SOP	standard operating procedure
SPA	Safety Program Assistant
SSC	Site Safety Coordinator
SSHP	site safety and health plan
STS	standard threshold shift
TBD	to be determined
TCE	trichloroethene
TeCa	tetrachloroethane
TLV	threshold limit value
UFP-QAPP	Uniform-Federal Policy-Quality Assurance Project Plan
UL	Underwriters Laboratory

USACE	U.S. Army Corps of Engineers
VI	vapor intrusion
VOC	volatile organic compound

Health and Safety Plan Statement

Site Safety and Health Plan

Introduction

This Site Safety and Health Plan (SSHP) presents the hazards known or anticipated to be present during the contracted remedial investigation (RI) tasks (see Section 2.4). The scoped RI field activities are planned for completion by March 2014 but may be subject to change based on results of the field activities and other extenuating circumstances (i.e., field conditions, stakeholder decision-making process, accessibility issues, etc.). This SSHP will be used by CH2M HILL to identify and mitigate task-specific hazards and select appropriate health and safety protective measures.

The SSHP contains information pertinent to the general conditions at the site and adjacent select offsite properties, such as general site information, hazard evaluation and control, personnel responsibilities and requirements, a general description of personal protective equipment (PPE), customary decontamination procedures, and emergency response procedures. Onsite personnel directly involved with the scoped field activities, as well as visitors entering the site, must review the SSHP and sign an agreement to comply with its provisions prior to commencing onsite work. The SSHP is considered an operational document that is subject to revisions in response to various site-specific conditions that may be encountered. However, these documents may be modified or updated only with the approval of the Health and Safety Manager (HSM) and project manager (PM).

Policy

This document was written based on the anticipated hazards and expected work conditions, and applies to field activities to be performed under the Uniform Federal Policy-Quality Assurance project Plan (UFP-QAPP). Applicability of this SSHP extends to all CH2M HILL employees, subcontractors, and visitors entering the site.

This project-specific SSHP will, at a minimum, meet the requirements under Occupational Safety and Health Administration (OSHA) Standard *29 Code of Federal Regulations* (CFR) 1910 & 1926 and the U.S. Army Corps of Engineers (USACE) EM 385-1-1 (USACE 2008), *Safety - Safety and Health Requirements*.

Pre-entry Requirements

During site mobilization, the Site Safety Coordinator (SSC) will perform a reconnaissance of the site and select offsite properties as identified in the site-specific UFP-QAPP to evaluate and determine the chemical, physical, and environmental hazards; establish or confirm emergency points of contact and procedures; and review any other issues deemed necessary to address site health and safety. The SSC will then conduct a health and safety briefing with the site personnel to discuss data obtained from the previous site reconnaissance, provisions outlined in this SSHP, and appropriate health and safety procedures and protocols.

CH2MHILL

Project HS&E Change Management Form

*This evaluation form should be reviewed on a **continuous** basis to determine whether the current site health and safety plan adequately addresses ongoing project work, and it should be completed whenever new tasks are contemplated or changed conditions are encountered.*

Project Task: RI/FS Activities for Operable Unit 2

Project Number: Project/Task Manager: Chris English

	Evaluation Checklist	Yes	No
1.	Has the CH2M HILL staff listed in the original SSHP changed?		
2.	Has a new subcontractor been added to the project?		
3.	Is any chemical or product to be used not listed in Attachment 2 of the plan?		
4.	Have additional tasks been added to the project that were not originally addressed in Section 2.6 of the SSHP?		
5.	Have new contaminants or higher than anticipated levels of original contaminants been encountered?		
6.	Has other safety, equipment, activity, or environmental hazard been encountered that are not addressed in Section 2.7 of the plan?		

If the answer is "YES" to Questions 1-3, an SSHP revision is NOT needed. Please take the following actions:

- Confirm that staff's medical and training status is current—check training records at http://www.int.ch2m.com/hands (or contact your regional Safety Program Assistant [SPA]), and confirm subcontractor qualifications.
- Confirm with the project contract administrator that subcontractor safety performance has been reviewed and is acceptable.
- Confirm with the CH2M HILL Health, Safety, and Environment (HS&E) Manager that subcontractor safety procedures have been reviewed and are acceptable.

If the answer is "YES" to Questions 4-6, an SSHP revision MAY BE NEEDED. To determine if revision is needed please contact Health, Safety, and Environment (HS&E) directly.

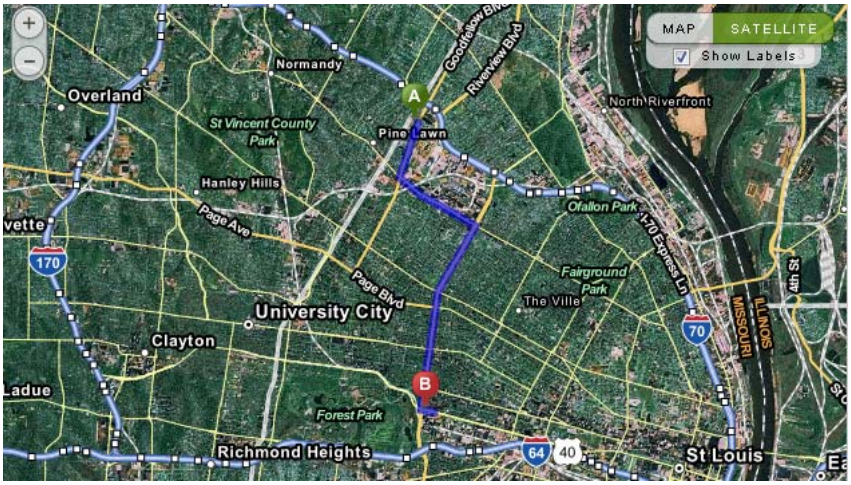
Route to Hospital Map

In case of an emergency **contact the police, fire, and medical emergency dispatch by dialing 911.** If medical care is needed but it is not an emergency, the name, address, phone number, and map to the nearest hospital is provided below.

FIGURE 1
Route to Hospital Map

Barnes-Jewish Hospital (South)
4921 Parkview Pl
Saint Louis, MO 63110
(314) 747-3000 Website More Info

The route from the site to the hospital is as follows:



A **4671 Goodfellow Blvd**, St Louis, MO 6312038.697259,-90.266974
(Address is approximate)

1.	Start out going **south** on **Goodfellow Blvd** toward **Edelle Ave**. Map	**0.8 Mi** *0.8 Mi Total*
2.	Take the 3rd **left** onto **Natural Bridge Ave**. Map *Natural Bridge Ave is just past Ferris Ave* *Yet Bun Chop Suey is on the corner* *If you are on Goodfellow Ave and reach Selber Ct you've gone about 0.1 miles too far*	**1.2 Mi** *2.0 Mi Total*
3.	Turn **right** onto **N Kingshighway Blvd**. Map *N Kingshighway Blvd is 0.1 miles past Norwood Ave* *If you reach N Euclid Ave you've gone about 0.1 miles too far*	**2.7 Mi** *4.7 Mi Total*
4.	Turn **left** onto **Forest Park Ave**. Map *If you reach Park View Pl you've gone a little too far*	**0.2 Mi** *4.9 Mi Total*
5.	Make a **U-turn** onto **Forest Park Ave**. Map *If you reach S Taylor Ave you've gone about 0.1 miles too far*	**0.01 Mi** *5.0 Mi Total*
6.	Keep **right** at the fork to continue on **Forest Park Ave**. Map	**0.08 Mi** *5.0 Mi Total*
7.	**4949 FOREST PARK AVE** is on the **right**. Map *If you reach S Kingshighway Blvd you've gone a little too far*	

B **4949 Forest Park Ave**, Saint Louis, MO 63108-1401

Total Travel Estimate: **5.04 miles - about 13 minutes**

Project Contacts List

This form shall be completed and updated as necessary by the SSC. A copy of the completed form shall be posted in a prominent location onsite, or in site vehicles.

Client: USACE—Kansas City District

Project/Site Name: RI/FS for Operable Unit 2 (Vapor Intrusion Pathway), St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Project Number: 459603

Project Contacts	Name	Phone Number	Cell Number
CH2M HILL PM	Chris English	314-335-3012	314-749-1550
CH2M HILL Assistant Project Manager/Quality Control Systems Manager (QCSM)	Tony Swierczek	314-335-3043	618-550-1244
CH2M HILL Field Team Leader/SSC/Quality Control (QC) Officer	Glynn Roberts	314-335-3038	314-324-4161
Principal Technologist/Sr. Project Engineer	Loren Lund	208-357-5351	208-821-1932
CH2M HILL HSM	Mark Orman	414-847-0597	414-712-4138
CH2M HILL Environmental Compliance Coordinator (ECC)	Jennifer Lindquist	530-229-3224	530-209-2234

CH2M HILL Subcontractors Contact List (Not applicable at this time)

Subcontractor	Primary Task	Site Manager	Phone	Safety Rep.	Phone
The Underground Detective	Private Utility Locating	To be determined (TBD)	TBD	TBD	TBD
Roberts Environmental Drilling, Inc.	Drilling/Monitoring Well Installation	TBD	TBD	TBD	TBD
TBD	Surveying	TBD	TBD	TBD	TBD
Applied Technologies	Waste Transporter	TBD	TBD	TBD	TBD

Client Contractors Contact List

Contractor Name	Primary Task	Contact	Phone
None			

1. Signature Sheet

This SSHP has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified, and must be amended if those conditions change.

1.1 Original Plan

Written By: Glynn Roberts Date: 12 September 5

Approved By: Mark Orman, CSP Date: 12 November 2012

2. Background Information

2.1 Project Information and Description

Project Number: 459603

Contract Number: W912DQ-11-D-3005 Task Order 0009

Client: USACE—Kansas City District

Project Name and Address: St. Louis Ordnance Plant, Former Hanley Area, St. Louis, Missouri

Project Manager: Chris English

CH2M HILL Office: STL

Date (SSHP) Prepared: 9/5/2012

Dates of Site Work: TBD

2.2 Site Description and History

The St. Louis Ordnance Plant operated from 1941 to 1945 as a small arms manufacturing facility. The plant was divided into two areas designated No.1 (east of Goodfellow Boulevard) and No. 2 (west of Goodfellow Boulevard). The former Hanley Area consists of 14.68 acres at the northeastern of Plant Area No. 2 at the intersection of Stratford Avenue and Goodfellow Boulevard. The former Hanley Area takes its name from Hanley Industries, Inc., which leased the 14.68 acres in 1959 and conducted operations there through 1979. Hanley used the site for research, development, manufacture, and testing of various explosives.

The former Hanley Area is bordered by the Job Corps Training Center on the west and residential areas to the north, west, and southwest. The area to the east, across Goodfellow Boulevard from the site, is now owned by the General Services Administration.

Ammunition and explosives manufacturing operations at the former Hanley Area resulted in soil and sediment contamination onsite and groundwater contamination onsite and offsite. Between 1979 and 2007, various environmental investigations were performed at the former Hanley Area to assess the nature and extent of contamination. In 2008, the Army conducted an RI to fill data gaps from the previous investigations. The RI objectives were to delineate the nature and extent of contamination and to characterize the risk, if any, posed to human health and the environment at the site. To address unacceptable human health risks identified in the RI report, the Army performed a remedial action for operable unit (OU) 1 in 2012. The OU-1 remedial action addressed contamination in soil, sediment, and groundwater. However, offsite groundwater contamination remains, and the potential for contaminant migration into offsite residences and non-residential buildings exists. The vapor intrusion (VI) pathway is the focus of the OU-2 RI/feasibility study (FS).

2.3 Description of Work

2.3.1 General Overview

The primary objective for OU-2 is to evaluate the VI pathway and implement appropriate remedial actions, if necessary, to protect human health and the environment. To achieve the objectives presented in the UFP-QAPP, the RI will assess the VI pathway at select offsite residences north of the former Hanley Area. In addition, the RI will assess potential VI impacts associated with Plume C, an onsite groundwater plume consisting primarily of carbon tetrachloride, near the Job Corps training facility located west of the former Hanley Area. The proposed sampling activities will consist of air sampling in the onsite tunnel system, subslab

soil gas sampling, indoor and outdoor air sampling, monitoring well installation, and groundwater sampling, in accordance with the UFP-QAPP. Field activities are scheduled to begin in 2013.

- Refer to Section 12.6.2 and 17.1 for information regarding activity hazard analysis (AHA) preparation, training, and use for visual inspection and all other tasks associated with this project.

2.4 Tasks to be Performed under This Plan

2.4.1 Description of Tasks

2.4.1.1 Building Surveys and Chemical Inventories

Building surveys and chemical inventories will be completed for offsite properties scheduled for sampling.

2.4.1.2 Air Sample Collection

Air samples will be collected from multiple offsite properties and from inside the onsite tunnel system. The following types of air samples will be collected: subslab soil gas, indoor air, and outdoor air. Samples will be analyzed for select volatile organic compounds (VOCs) via method TO15-SIM that have been identified as potentially present in groundwater beneath the north part of the former Hanley Area.

2.4.1.3 Monitoring Well Installation and Groundwater Sampling

Collocated shallow and deep overburden monitoring well pairs will be installed offsite along Stratford Avenue (located north of the former Hanley Area), in the back yard of a residence located on Henner Avenue, and onsite near Plume C. The possibility exists that co-located monitoring well pairs could be installed near the south and west sides of a day care center located north of the former Hanley Area. Groundwater samples will be analyzed for select VOCs by Method 8260B.

2.4.1.4 Investigation-derived Waste Management

Soil cuttings, decontamination water, and purge water generated during field activities will be managed in accordance with the UFP-QAPP.

2.5 Task Hazard Analysis

The following table identifies the specific task to be performed on this project and the potential significant hazards associated with each task. Additional “general” hazards are identified in Section 13.

Potential Hazards	Project Activities			Groundwater Sampling
	Air Sampling	Monitoring Well Installation	Site Inspections	
Biological hazards	X	X	X	X
Chemical Hazard-Dermal/ Inhalation	X	X	X	X
Dust Hazard (Silica/Metals)		X		
Fire/Explosion Hazards		X		
Hand & Power Tools	X	X		X
Electrical, shock	X	X		
Manual Lifting	X	X		X
Noise	X	X		
Utilities (underground/overhead)		X		
Vehicle Traffic	X	X	X	X
Visible Lighting	X	X	X	X
Weather	X	X	X	X

3. Responsibilities and Lines of Authority

3.1 Client

Client Name: USACE–Kansas City District
Contact Name: Josephine Newton-Lund
Job Title: PM
Phone Number: 816-389-3912

3.2 Project Management Staff

3.2.1 Project Manager

PM Name: Chris English
Office: STL
Phone Number: Office: 314-335-3012 Cell: 314-749-1550

The PM is responsible for providing adequate resources (budget and staff) for project-specific implementation of the HS&E management process. The PM has overall management responsibility for the tasks listed below. The PM may explicitly delegate specific tasks to other staff, as described in sections that follow, but retains ultimate responsibility for completion of the following in accordance with this document:

- Incorporate standard terms and conditions and contract-specific HS&E roles and responsibilities in contract and subcontract agreements (including flow-down requirements to lower-tier subcontractors).
- Select safe and competent subcontractors.
- Obtain, review, and accept or reject subcontractor prequalification questionnaires.
- Ensure that acceptable certificates of insurance are secured as a condition of subcontract award.
- Incorporate HS&E information in subcontract agreements, and ensure that appropriate site-specific safety procedures, training, and medical monitoring records are reviewed and accepted prior to the start of subcontractor's field operations.
- Maintain copies of subcontracts and subcontractor certificates of insurance, bond, contractor's license, training and medical monitoring records, and site-specific safety procedures are in the project file accessible to site personnel.
- Provide full-time oversight of subcontractor HS&E practices per the site-specific safety plan.
- Manage the site and interface with third parties in a manner consistent with our contract and subcontract agreements and the applicable standard of reasonable care.
- Ensure that the overall, job-specific HS&E goals are fully and continuously implemented.
- Issue Site Safety Rules consistent with this plan.

3.2.2 Project Certified Safety Professional and Health and Safety Manager

Name: Mark Orman
Office: MKE
Phone Number: Office: 414-847-0597 Cell: 414-712-4138

The project-certified Certified Safety Professional (CSP)/Health and Safety Manager (HSM) is responsible for the following:

- Review and accept or reject subcontractor prequalification questionnaires.

- Review and accept or reject subcontractor training records and site-specific safety procedures prior to start of subcontractor's field operations.
- Support the SSC's oversight of subcontractor (and lower-tier subcontractors) HS&E practices and interfaces with onsite third parties per this site-specific SSHP and the Accident Prevention Plan (APP).
- Provide project oversight to assess site conditions and review HS&E program implementation.
- Assist project team with program implementation.

3.2.3 Project Site Safety Coordinator Responsibilities

Name: Glynn Roberts
Office: STL
Phone Number: Office: 314-335-3038 Cell: 314-324-4161

The project SSC shall be onsite for the duration of construction activity and share in the responsibility to:

- Make safety integral to each operation by promoting worker involvement in the work planning and hazard identification process.
- Maintain active and visible involvement using open communication with employees regarding safety items on the project.
- Review and understand contractual obligations regarding HS&E.
- Manage the site and interface with third parties in a manner consistent with our contract agreements and the applicable standard of reasonable care.
- Verify this SSHP is current and amended when project activities or conditions change.
- Verify site personnel and subcontractor supervision read this SSHP and sign the Employee Signoff Form in Attachment 1 prior to commencing field activities.
- Verify and document that team members have completed any required specialty training (for example, fall protection, confined space entry) and medical surveillance.
- Assure that the workforce is trained and qualified.
- Conduct an HS&E orientation for all team members prior to entering the project work areas.
- Verify compliance with the requirements of this SSHP and applicable contractor SSHP, USACE EM 385-1-1 Manual, and federal, state, and local regulations.
- Act as the project "Hazard Communication Coordinator" and perform the responsibilities outlined in this plan.
- Act as the project "Emergency Response Coordinator" and perform the responsibilities outlined in this plan.
- Post required information and jobsite posters as required at sites where project field offices, trailers, or equipment-storage boxes are established.
- Verify that safety meetings are conducted and documented in the project file as needed throughout the course of the project (for example, as tasks or hazards change).
- Verify that project health and safety forms and permits are being used as outlined in this plan.
- Perform assessments of contractor HS&E practices per the task specific AHAs, this plan and verify that project activity self-assessment checklists are being used. Provide weekly HS&E project reports to the PM.
- Verify that project files available to site personnel include copies of executed contracts and certificates of insurance, bond, contractor's license, training and medical monitoring records, and site-specific safety procedures prior to start of subcontractor's field operations.

- Verify appropriate PPE use, availability, and training.
- Conduct safety briefings weekly for team members and subcontractor supervisors.
- Notify a Human Resources representative and Program Certified Industrial Hygienist (CIH)/HSM of injuries and follow up on injured employee's progress.
- Conduct accident investigations including root cause analysis.
- Maintain HS&E records and documentation.
- Facilitate USACE inspector or other government agency inspections including accompanying inspector and providing all necessary documentation and follow-up.
- Deliver field HS&E training as needed based on project-specific hazards and activities.
- Ensure that programs are effectively functioning to prevent and control hazards on the project.

3.2.4 Subcontractor Site Safety Coordinator Responsibilities

The subcontractor will provide an SSC who will have completed at least an OSHA, or equivalent, 10-hour construction safety course. Each subcontractor must comply with the following activities and is responsible for the following at a minimum:

Subcontractors must comply with the following activities, and are responsible to:

- Provide appropriately trained personnel to serve as SSCs.
- Make safety integral to each operation by promoting worker involvement in the work planning and hazard identification process.
- Comply with the SSHP, USACE EM 385-1-1 Manual, Recognized Safety Rules, or other local safety standards.
- Comply with project and owner safety requirements.
- Attend and actively participate in daily health and safety meetings to discuss new issues, health and safety compliance, lessons learned, and any open deficiencies noted on the project.
- Maintain a first-aid kit onsite.
- Maintain active and visible involvement using open communication with employees regarding safety items on the project site.
- Coordinate with the HSM regarding subcontractor operational performance, and third party interfaces.
- Verify appropriate PPE use, availability, and training.
- Maintain and replace safety protection systems damaged or removed by the subcontractor's operations.
- Notify the HSM of any accident, injury, and/or incident immediately and submit reports to the prime contractor within 24 hours.
- Verify that project health and safety forms and permits are being used as outlined in the SSHP and APP.
- Install contractually required general conditions for safety (for example, handrail, fencing, fall protection systems, floor opening covers, etc.).
- Conduct and document weekly safety inspections of project-specific tasks and associated work areas.
- Conduct daily employee safety toolbox meetings and provide copies to the HSM.
- Conduct site-specific orientations for all subcontractor and client employees, as requested.

3.2.5 CH2M HILL Project Environmental Manager

Environmental Manager (EM) Name: Jenny Lindquist
Telephone Number: +1 (530) 229-3224
Cellular Number: +1 (530) 209-2234

The Project EM is responsible for the following:

- Provide environmental program support in areas such as training, auditing, planning, permit tracking, and subcontractor oversight as needed or as specified in the project environmental plan.
- Review and evaluate qualifications for subcontractors with a history of environmental non-compliance and for waste transportation and disposal subcontractors.
- Evaluate any spills, releases, or environmental permit incidents for appropriate follow-up actions, notifications, and recordkeeping requirements.
- Provide environmental compliance and environmental management expertise and advice to the project team as needed during the course of the project.

3.2.6 Employee Responsibilities

All personnel are assigned responsibility for safe and healthy operations. This concept is the foundation for involving all employees in identifying hazards and providing solutions. For any operation, individuals have full authority to stop work and initiate immediate corrective action or control. In addition, each worker has a right and responsibility to report unsafe conditions and practices. This right represents a significant facet of worker empowerment and program ownership. Through shared values and a belief that all accidents are preventable, our employees accept personal responsibility for working safely.

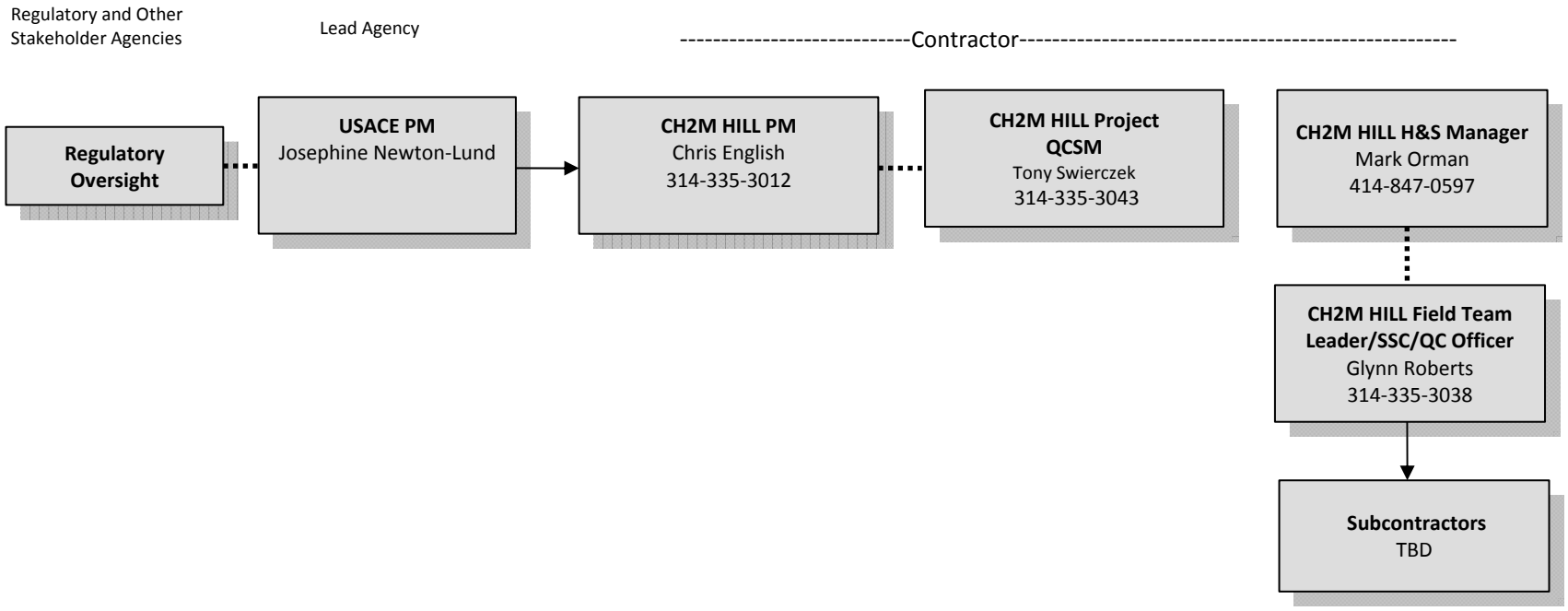
Each employee is responsible for the following performance objectives:

- Perform work in a safe manner and produce quality results.
- Perform work in accordance with company policies, and report injuries, illnesses, and unsafe conditions.
- Complete work without injury, illness, or property damage.
- Report all incidents immediately to the supervisor and file proper forms with a Human Resources representative.
- Report all hazardous conditions and/or hazardous activities immediately to the supervisor for corrective action.
- Complete an HS&E orientation prior to being authorized to enter the project work areas.

3.2.7 Employee Authority

Each employee on the project has the obligation and authority to shut down any perceived unsafe work, and each employee will be informed of their authority to do so during employee orientation.

3.3 Lines of Authority



4. Subcontractors and Suppliers

(Reference CH2M HILL Standard Operation Procedure [SOP] HSE-215, *Contracts, Subcontracts and HSE&Q Management Practices*)

4.1 Subcontractors

Subcontractor:	Underground Detective
Task:	Private utility locating
Contact Name:	TBD
Telephone:	TBD
Subcontractor:	Roberts Environmental Drilling, Inc.
Task:	Drilling and monitoring well installation
Contact Name:	TBD
Telephone:	TBD
Subcontractor:	TBD
Task:	Surveying
Contact Name:	TBD
Telephone:	TBD
Subcontractor:	Applied Technologies
Task:	Waste transportation and disposal
Contact Name:	TBD
Telephone:	TBD
Subcontractor:	TBD
Task:	Air sampling in tunnel system
Contact Name:	TBD
Telephone:	TBD

4.2 Subcontractor Responsibilities

The subcontractor listed above is covered by this SSHP and the APP and must be provided a copy of these documents. If subcontractors have specific hazards associated with their type of work that are not covered by this SSHP and the APP, the subcontractors are responsible to submit the procedures to cover these hazards to the prime contractor for review before the start of field work. Minimal submittals are specific AHAs related to the subcontractor tasks.

Subcontractors must comply with the SSHP and the APP. The HSM should verify that subcontractor employee training, medical clearance, and fit test records are current and must monitor and enforce compliance with the established plan(s). The prime contractor's oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

4.3 Health and Safety Interaction with Subcontractor

Team members should continuously endeavor to observe subcontractors' safety performance. This endeavor should be reasonable and include observation of hazards or unsafe practices that are both readily observable and occur in common work areas. The prime contractor is not responsible for exhaustive observation for hazards and unsafe practices. In addition to this level of observation, the SSC is responsible for confirming subcontractor performance against both the subcontractor's task-specific safety procedures (that is, AHAs) and

applicable self-assessment checklists. Self-assessment checklists, provided in Attachment 5, are to be used by the HSM and designated SSCs to review performance.

Health and safety-related communications with the subcontractor should be conducted as follows:

- Brief subcontractor and employees on the provisions of this plan, and require them to sign the Employee Signoff Form, included in Attachment 1.
- Request the subcontractor to brief project team on the hazards and precautions related to their work.
- When apparent non-compliant or unsafe conditions or practices are observed, notify the subcontractor safety representative and require corrective action—the subcontractor is responsible for determining and implementing necessary controls and corrective actions.
- When repeat noncompliant or unsafe conditions are observed, notify the subcontractor safety representative and stop affected work until adequate corrective measures are implemented.
- When an apparent imminent danger exists, immediately remove all affected personnel, notify the subcontractor safety representative, stop affected work until adequate corrective measures are implemented, and notify the PM and HSM as appropriate.
- Document all verbal health and safety-related communications in project field logbook, daily reports, or other records.

5. Training

5.1 Employee Training

The intent of employee training program is to ensure that employees receive the appropriate level of training to conduct their work in a safe manner and to comply with applicable regulations. All employees are required to maintain the training qualification necessary to perform their assigned duties and job functions. Guidance on required courses can be obtained from the HSM and CH2M HILL SOP HSE-110, *Health, Safety, and Environment Training*.

5.2 Training Requirements

5.2.1 Hazardous Waste Operations Training

All employees engaging in hazardous waste operations or emergency response shall receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65. At a minimum, the training shall have consisted of instruction in the topics outlined in 29 CFR 1910.120 and 29 CFR 1926.65. Personnel who have not met these training requirements shall not be allowed to engage in hazardous waste operations or emergency response activities.

5.2.1.1 Initial Training

General site workers engaged in hazardous waste operations shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for hazardous waste site operations, unless otherwise noted in the above-referenced standards.

Employees engaged in emergency response operations shall be trained to the level of required competence in accordance with 29 CFR 1910.120.

5.2.1.2 Three-Day Actual Field Experience

General site workers for hazardous waste operations shall have received three days of actual experience (on-the-job training) under the direct supervision of a trained, qualified supervisor and shall be documented. If the field experience has not already been received and documented at a similar site, this supervised experience shall be accomplished and documented at the beginning of the assignment of the project.

5.2.1.3 Refresher Training

General site workers shall receive 8-hours of refresher training annually (within the previous 12-month period) to maintain qualifications for fieldwork. Employees engaged in emergency response operations shall receive annual refresher training of sufficient content and duration to maintain their competencies or shall demonstrate competency in those areas at least annually.

5.2.1.4 Eight-Hour Supervisory Training

On site management or supervisors who will be directly responsible for, or supervise employees engaged in hazardous waste site operations, will have received at least 8 hours of additional specialized training on managing such operations. Employees designated as Safety Coordinator – Hazardous Waste are considered 8-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) Site Safety Supervisor trained.

5.2.2 First-aid/Cardiopulmonary Resuscitation

First-aid and cardiopulmonary resuscitation (CPR) training consistent with the requirements of a nationally recognized organization such as the American Red Cross Association, American Heart Association, or National Safety Council shall be administered by a certified trainer. A minimum of two personnel per active field

operation will have first-aid and CPR training. Bloodborne pathogen training located on CH2M HILL's Virtual Office is also required for those designated as first-aid/CPR trained.

5.2.3 Site Safety Coordinator Training

SSCs are trained to implement the HSE program on CH2M HILL field projects. A qualified SSC is required to be identified in the site-specific SSHP for CH2M HILL field projects. SSCs must also meet the requirements of the worker category appropriate to the type of field project (construction or hazardous waste). In addition, the SSCs shall have completed additional safety training required by the specific work activity on the project that qualifies them to implement the HSE program (for example, fall protection, excavation).

5.2.4 Site-specific Training

Prior to commencement of field activities, all field personnel assigned to the project will have completed site-specific training that will address the contents of applicable SSHPs, including the activities, procedures, monitoring, and equipment used in the site operations. Site-specific training will also include site and facility layout, potential hazards, risks associated with identified emergency response actions, and available emergency services. This training allows field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safety and work operations for their particular activity.

5.2.5 Project-specific Training Requirements

Project-specific training for this project includes:

- SSHP/APP/AHAs
- Ladder Safety

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL's SOP, *Reproduction Protection*, including obtaining a physician's statement of the employee's ability to perform the assigned activities before being assigned fieldwork.

5.3 Subcontractor Personnel Qualifications

All subcontractors will provide the HSM with a list certifying the training and qualifications of competent persons and qualified operators for the following activities/equipment.

5.3.1 Competent Persons/Qualified Operators

- TBD

5.3.2 Activity/Equipment List

- TBD

5.4 Project Employee Orientation

Employees expecting to access the site are required to have the project employee orientation. The training will be provided by the SSC. The training provided to the employees in the employee orientation shall include the following:

- Review the SSHP and APP.
- Present an overall site safety briefing (general site safety).
- Review employee responsibilities.
- Review AHA policies and procedures.
- Review emergency procedures and evacuation plan.
- Review injury and incident reporting procedures.
- Review reporting procedures for hazardous conditions and/or hazardous activities.

5.5 Personal Protective Equipment Training

OSHA requires each PPE user to receive training on the proper care, maintenance, limitations, and instructions on how to wear and adjust PPE. The proper use of PPE will also be included in project safety briefings and toolbox meetings.

5.6 Safety Meetings and Toolbox Meetings

Safety meetings provide a method for maintaining safety awareness and providing safety-related information and training to employees. Safety meetings for project supervisory personnel and project employees shall be held at least daily and include relevant information for on- and off-the-job safety.

5.7 Activity Hazard Analysis Training

Each supervisor will review task-specific AHAs with all workers assigned to perform that task prior to the beginning of that task anywhere on the job site. All workers will sign the AHA document signifying they have been trained and understand the task steps, hazards, and hazard controls to be used.

5.8 Safety Pre-task Planning and Training

Each day, the onsite supervisors shall hold informational safety training with each member of their crew. Information discussed and training performed shall pertain to current project activities and scope of work. The subcontractor is encouraged to use this time for employee input and task-specific training.

5.9 Vendor Training

Vendors that supply equipment to the project will be required to perform a training session to review and explain the safe operation procedures to the parties that will be using or operating the equipment.

5.10 Emergency Response Plan Training

Emergency Response Plan (ERP) training will occur during the employee orientation and retraining will occur periodically in safety meetings. The ERP training will include evacuation alarms, site evacuation, designated evacuation assembly areas, and route to emergency medical facility. Emergency drills will be performed initially, but at least twice per year. See Section 12 for the Emergency Preparedness procedures.

5.11 Conduct of Training

5.11.1 Instructor/Trainer Requirements

All personnel who will conduct training will have documented expertise in the areas of which they will be conducting the training as well as knowledge of the regulatory and other requirements. They will also be listed as a competent person in that area by the employer or contractor.

5.11.2 Initial Training

All employees will have documentation of initial training required to perform their assigned duties with their assigned tools and equipment. If previous documentation or subcontractor certification is not available, then initial training will take place onsite prior to the employee commencing work.

5.11.3 Re-training

Re-training will be required under the following conditions:

- There is a change in operations or equipment capabilities.
- An employee is seen performing an unsafe act, or operating equipment or machinery in an unauthorized manner.
- There is an incident or accident on the job site.
- Anytime the regulatory requirements require refresher training due to time periods, such as HAZWOPER, etc.

5.11.4 Demonstrated Competency

For all training conducted for equipment, machinery, or hazardous activities, the trainer will document in writing that the individual has “demonstrated competency” in the areas required to perform their assigned tasks safely and in compliance with the regulatory and other guidance.

5.12 Documentation

All training shall be documented. Documentation and certificates verifying completion will be maintained onsite by the employer and copies of the training documentation will be submitted to the HSM. Training documentation will be made available for review at all times.

6. Health and Safety Inspections

6.1 General Requirements

In addition to the hazard controls specified in this document, Project Activity Self-Assessment Checklists are contained in Attachment 5. Any site-specific requirements outlined in this SSHP and APP that are more stringent than those contained in the Project-Activity Self-Assessment Checklists are to take precedence. The Project Activity Self-Assessment Checklists are based upon minimum regulatory compliance and some site-specific requirements may be more stringent. The subcontractor shall use these checklists to assess the adequacy of site-specific safety requirements and determine whether employees will be safe. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. The self-assessment checklists, including documented corrective actions, shall be made part of the permanent project records and maintained by the SSC.

The self-assessment checklists will also be used by the SSC in evaluating the subcontractors' compliance onsite.

If hazardous conditions exist or are apparent during the self-assessment, immediately notify the employees in the area and do not continue work in that area. If an imminent danger situation exists that is immediately life threatening or would cause serious injury, immediately stop work and warn the contractor employee(s) in danger and notify the contractor safety representative and report it to the SSC.

Self-assessment checklists should be completed and permit-to-work reviewed prior to exposure of the activities outlined below. Self-assessments shall be completed prior to subjecting personnel to hazardous operations for any reason. Follow-up self-assessments shall be conducted on a weekly basis and more frequent if conditions warrant.

The following list of hazardous activities identifies those most commonly found on construction sites. Each of the following Project Activity Self-Assessment Checklists are found in Attachment 5. The SSC is responsible for identifying site-specific hazardous activities not included in this list (for example, chlorine safety, tunneling, traffic control, etc.) and integrate methods for verifying compliance with established safe work practices, regulations, and industry standards pertaining to those additional site-specific hazardous activities.

- Hand and Power Tools
- Drilling

6.2 Conduct of Inspections

6.2.1 Personnel Authorized to Conduct Inspections

All onsite supervisors are authorized to perform informal inspections of any project activity and make corrections as required. If anyone witnesses an unsafe act or what they believe to be an unsafe act, they are obligated to intercede and prevent the act from occurring. Once they have accomplished that, they will immediately notify the SSC or HSM, who will conduct a formal review of the actions.

The following individuals are authorized to conduct formal Health and Safety inspections onsite for CH2M HILL:

- CH2M HILL SSC
- CH2M HILL HSM

6.2.2 Observed Hazard Form/Safe Work Observation Form

The SSC will perform daily site safety inspections to verify that the project is conducted in a safe manner. The SSC will keep a daily log to track the health and safety observations. In addition to the SSC's daily log, hazards that are discovered by the SSC will be documented on the Safe Work Observation Form (Attachment 10).

6.2.3 Self-Assessment Checklists

The SSC will be responsible for conducting formal inspections of the work site(s) periodically throughout the work week. These inspections will focus on activities covered by self-assessment checklists, but can be expanded to cover all aspects of health and safety on the work site(s).

The self-assessment checklists (Attachment 5) will be used as a guide to determine compliance with recognized health and safety standards. The following four entries can be entered on the checklists:

- **YES**—In compliance
- **NO**—Not in compliance
- **N/A**—Not Applicable to current operation
- **N/O**—Not observed during this period

6.3 Deficiency Tracking System

6.3.1 Safe Behavior Observation Forms

All observed hazard forms will be completed onsite at the time of the observed hazard, or activity inspection. Both good behaviors and questionable or unsafe behaviors will be annotated on the form and discussed with the observed worker(s). Any unsafe behavior or acts observed will be documented in writing to the subcontractor's PM for action. All observed hazard forms will become a permanent part of the project files.

6.3.2 Self-Assessment Checklists

Any item that is annotated with a "NO" must be explained on the last sheet of the checklist, and followed up for corrective action. The last page of each checklist has a column for recording the date the deficiency was corrected. These self-assessment checklists—once completed and signed by the inspector, reviewed with the applicable supervisor and/or employee, and signed by the PM—will become a permanent record of inspection and part of the project files.

6.3.3 Open Deficiencies

All self-assessment checklists with open deficiencies or stop work orders will be the top priority for the SSC each workday to ensure they are corrected, any training accomplished, or the situation corrected to close out the deficiency. If the deficiency is not handled in a timely manner, the SSC will report the problem in writing to the Prime Contractor PM.

A copy of the Safety and Occupational Health deficiency tracking log shall be mounted on or be adjacent to the bulletin board or a notice on the bulletin board shall state the location where it may be accessed by all workers upon request. See Attachment 12 for the form.

7. Health and Safety Expectations, Incentive Program, and Compliance

7.1 Safe Work Policy

It is policy to perform work in the safest manner possible. Safety must never be compromised. To fulfill the requirements of this policy, an organized and effective safety program must be carried out at each location where work is performed.

CH2M HILL believes that all injuries are preventable and we are dedicated to the goal of a safe work environment. To achieve this goal, every employee on the project must assume responsibility for safety.

Every employee is empowered to:

- Conduct their work in a safe manner.
- Stop work immediately to correct any unsafe condition that is encountered.
- Take corrective actions so that work may proceed in a safe manner.

Safety, occupational health, and environmental protection will not be sacrificed for production. These elements are integrated into quality control, cost reduction, and job performance and are crucial to project success.

7.2 Health and Safety Commitment

CH2M HILL has embraced a philosophy for health and safety excellence. The primary driving force behind this commitment to health and safety is simple: employees are the company's most significant asset and management values their safety, health, and welfare. Also, top management believes that all injuries are preventable. The safety culture empowers employees at all levels to accept ownership for safety and take whatever actions are necessary to eliminate injury. Our company is committed to world-class performance in health and safety, and understands that world-class performance in health and safety is a critical element in overall business success.

CH2M HILL is committed to the prevention of personal injuries, occupational illnesses, and damage to equipment and property in all of its operations; to the protection of the public whenever it comes in contact with the Company's work; and to the prevention of pollution and environmental degradation.

Company management, field supervisors, and employees plan safety into each work task in order to prevent occupational injuries and illnesses. CH2M HILL management extends its full commitment to health and safety excellence.

7.3 Project-Specific Health, Safety, and Environment Goals

All management and employees are to strive to meet the project-specific HS&E goals outlined below. The team will be successful only if everyone makes a concerted effort to accomplish these goals. The goals allow the project to stay focused on optimizing the health and safety of all project personnel and, therefore, making the project a great success.

The project has established eleven specific goals and objectives:

- Create an injury-free environment.
- Have zero injuries or incidents.
- Provide management leadership for HS&E by communicating performance expectations, reviewing and tracking performance, and leading by example.

- Ensure effective implementation of the SSHP and APP through education, delegation, and teamwork.
- Ensure 100-percent participation in training programs, PPE use, and HS&E compliance.
- Continuously improve safety performance.
- Maintain free and open lines of communication.
- Make a personal commitment to safety as a value.
- Focus safety improvements on high-risk groups.
- Continue strong employee involvement initiatives.
- Achieve health and safety excellence.

7.4 Standards of Conduct Violations

All individuals associated with this project must work injury-free and drug-free and must comply with the following Standards of Conduct, the SSHP and APP, and the site safety requirements. Commonly accepted standards of conduct help maintain good relationships between people. They promote responsibility and self-development. Misunderstandings, frictions, and disciplinary action can be avoided by refraining from thoughtless or wrongful acts. Violations of the standards of conduct would include, but not be limited to:

- Failure to perform work.
- Inefficient performance, incompetence, or neglect of work.
- Willful refusal to perform work as directed (insubordination).
- Negligence in observing safety regulations, poor housekeeping, or failure to report on-the-job injuries or unsafe conditions.
- Unexcused or excessive absence or tardiness.
- Unwillingness or inability to work in harmony with others.
- Discourtesy, irritation, friction, or other conduct that creates disharmony.
- Harassment or discrimination against another individual.
- Failure to be prepared for work by wearing the appropriate construction clothing or PPE, or bringing the necessary tools.
- Violation of any other commonly accepted reasonable rule of responsible personal conduct.

7.5 Intolerable Offenses

Certain employee conduct may be so intolerable as to justify removal from the project. Intolerable offenses and actions will include, but not be limited to, the following:

- Any manager, supervisor, foreman, or other person in charge of the work being performed who requires requests, asks, threatens with their job, allows, or condones employees to work in or around unsafe acts or conditions.
- Any employee, supervisor, or manager who knowingly falsifies any investigative documents or testimony involving an investigation.
- Any employee, supervisor, or manager who openly exhibits disregard, defiance, or disrespect for the safety program.
- Any employee who violates established safety rules, regulations, or codes that endanger themselves or other employees.

- Any and all parties involved in workplace violence, including physical encounters (fighting) or threats of violence, theft, or destruction of property.
- Any employee, supervisor, or manager failing to comply with procedures contained in the subcontract, SSHP and APP, USACE EM 385-1-1 Manual, or local safety laws and regulations that create the potential for serious or costly consequences.
- Any employee who commits repeated minor offenses and shows a lack of responsible effort to correct these offenses.

7.6 Enforcement and Discipline

CH2M HILL's Enforcement and Discipline procedures, the Standards of Conduct, the Intolerable Offenses, and the Drug-Free Workplace policy will be thoroughly reviewed with each employee during the employee project orientation.

7.6.1 Intolerable Offenses

CH2M HILL practices zero tolerance for intolerable offenses. Those individuals found participating in such offenses will be either suspended from work for 3 days without pay or immediately discharged and not allowed to return.

7.6.2 Other Violations

Other violations will be handled accordingly:

- First offense—employee will receive a written warning.
- Second offense—employee will receive a 2-day suspension without pay.
- Third offense—employee will be discharged.

7.7 Subcontractor Default

If the subcontractor fails to comply with any of the requirements of the subcontract, SSHP and APP, or local safety laws and regulations, the prime contractor may issue a stop work order to the subcontractor. Thereupon, the subcontractor shall immediately cease all work or portion of work that may be specifically designated in the stop work order until the prime contractor has concluded in writing that the subcontractor has corrected its failure of performance. No adjustments will be made to the subcontractor price or schedule as a result of any stop work orders being issued by the prime contractor. A stop work order will be given to the noncompliant subcontractor on the date of deficiency. If the subcontractor fails to correct the deficiencies noted in the stop work order within 3 working days following the written notice from the prime contractor, the prime contractor may, without prejudice to any other rights or remedies under the subcontract or at law or equity, suspend all further payments to subcontractor and/or terminate subcontractor's right to continue performance of the work.

7.8 Incentive Program

The prime contractor will encourage the subcontractor to implement a safety incentive program for the project that rewards workers for exhibiting exemplary safety behaviors. Actions that qualify are those that go above and beyond what is expected, like wearing your own safety equipment, seatbelt, etc. Actions that will be rewarded include spotting and correcting a hazard, bringing a hazard to the attention of your foreman, telling your foreman about an incident, coming up with a safer way to get the work done, stopping a crew member from doing something unsafe, etc. The program will operate throughout the project, covering all craft workers. The incentive program will be communicated to all employees during the project employee orientation and project safety meetings.

7.9 Posting of Health and Safety Information

As there will be no office facilities, posting will be available in vehicle of field team leader assessable to all on crew.

8. Accident Reporting

8.1 General Information

This section applies to the following:

- All injuries involving employees, third parties, or members of the public
- Damage to property or equipment
- Interruptions to work or public service
- Incidents that attract negative media coverage
- Near misses
- Spills, leaks, or regulatory violations
- Motor vehicle accidents

Documentation, including incident reports, investigation, analysis, and corrective measure taken, shall be kept by the SSC and maintained onsite for the duration of the project.

8.2 Section Definitions

Incident: an undesired event that results or could have resulted in loss through injury, damage to assets, or environmental harm. This includes “near misses,” “accidents,” and “dangerous occurrences.”

Accident: An incident involving actual loss through injury, damage to assets, or environmental harm.

Near Miss: An unsafe act or incident that, in other circumstances, could have resulted in loss through injury, damage to assets, or environmental harm.

Dangerous Occurrence: A dangerous occurrence complies in most respects with the definition of an accident, with the important difference being that, in a dangerous occurrence, there are no injuries suffered by personnel.

8.2.1 Major Incidents

- All fatalities, including contractors, subcontractors, third parties, or members of the public
- Serious injuries (see definition below) requiring hospitalization in excess of 24 hours, unless detained solely for observation
- Major stoppage of work for more than 24 hours
- Property damage in excess of $2,000
- Accidents that result or are likely to result in negative media or authorities’ attention
- Near misses with a high potential to result in any of the above losses

8.2.1.1 Serious Injury

- Fracture of a bone, including the skull, spine, or pelvis
- The loss of sight or an eye
- Any other injury, excluding occupational disease, that results in the person being hospitalized for more than 24 hours, unless detained solely for observation

Minor Injury: An injury that does not cause the injured person to lose any normal job time beyond the day or shift upon which the injury occurs.

Lost-time Injury: Any injury that causes the injured person to lose normal job time beyond the day or shift upon which the injury occurred.

8.3 Reporting Requirements

All employees and subcontractors' employees shall immediately report any incident (this includes "near misses," "accidents," and "dangerous occurrences" as defined in Section 9.2 above) in which they are involved or witness to their supervisor.

The supervisor, upon receiving an incident report, shall inform his immediate superior and the SSC.

The SSC shall immediately report the following information to the Program CSP/HSM and PM by phone, in person, and/or e-mail:

- Project name/site manager
- Date and time of incident
- Description of incident
- Extent of injuries/damage
- Level of medical attention
- Preliminary root cause/corrective actions

The SSC shall complete and forward the initial hard copy Incident & Near Loss Investigation Report Form ("Incident Report Form") and Root Cause Analysis Form to the Program CSP/HSM within 24 hours and finalize those forms within 3 calendar days. Examples of these forms are included in Attachment 11, Loss/Near-Loss Investigations.

Major accidents include any occupational hazard exposure or physical injury that requires more than basic first-aid (physical injury/exposure) or fire, explosion, or property damage exceeding $200,000. Major accidents require immediate notification of appropriate personnel as discussed below and must be done within 24 hours to the Contracting Officer/ Representative.

In the event of an injury that constitutes an OSHA-recordable incident, the SSC will notify the USACE PM, the onsite Area Environmental Protection Specialist, CH2M HILL PM, Compliance Safety and Health Officer (CSHO), and HSM as soon as practical after the incident. The reporting form shall be Contractor Safety Incident Report (CSIR), found in Attachment 11.

8.4 Investigation Requirements

The supervisor or SSC shall proceed to the scene of the incident, take charge of the situation to prevent further injury or damage, and arrange first-aid or medical treatment for the injured.

The supervisor shall ensure that no equipment, material, or other evidence of the incident is removed unless essential to prevent further injury or damage. The supervisor will also carry out an initial investigation of the incident.

The causes of loss and near loss incidents are similar, so by identifying and correcting the causes of near loss incidents, future loss incidents may be prevented. The following is the Loss/Near Loss Investigation Process:

- Gather all relevant facts, focusing on fact-finding, not fault-finding.
- Answer the "who, what, when, where, why, and how" questions.
- Put facts together into a probable scenario.
- Determine incident root cause(s), which are basic causes on why an unsafe act/ condition existed.
- Develop and implement solutions, matching all identified root causes with solutions.
- Communicate incident as a lesson learned to all project personnel.
- Follow up on implemented corrective active action to confirm solution is appropriate.

The supervisor and/or SSC shall perform an incident investigation, as soon as practical after the incident, for all Loss and Near Loss Incidents that occur on the project. Loss incident investigations shall be performed in accordance with the SOP HSE-111, *Incident Notification, Reporting and Investigation.* The following forms must be completed:

- Incident Report Form (Attachment 11)
- Root Cause Analysis Form (Attachment 11)

Provide a description of the event and the sequence of events and actions that took place prior to the incident. Start with the incident event and work backwards in time through all of the preceding events that directly contributed to the accident.

A preliminary Incident Report Form and Root Cause Analysis Form shall be submitted to the PM and Program CSP/HSM within 24 hours of incident occurrence. The final Incident Report From and Root Cause Analysis shall be submitted after completing a comprehensive investigation of the incident.

The PM and SSC shall evaluate the supervisor's investigation report and ensure that the report adequately addresses the facts and circumstances of the incident, the causes, and recommended corrective actions. If the initial investigation is considered inadequate, the PM shall appoint the SSC to carry out further investigation.

For a major incident, the senior management shall convene a committee of inquiry to conduct a thorough investigation into the incident. The team shall be provided with proper terms of reference to guide the scope of their investigation. The team shall include the PM, responsible Supervisor, SSC, and subcontractor, if applicable. The Program CSP/HSM reserves the right to participate in the investigation.

8.5 Analysis

The accident analysis is essential if all causes of the incident are to be identified for the correct remedial actions to be taken to prevent the same and similar type of incident from recurring. The investigation team will consist of the SSC, the responsible supervisor, and PM.

The Root Cause Analysis Form (Attachment 11) must be completed for all Loss Incidents and Near Loss Incidents. This form must be submitted to the investigation team for review.

For minor losses or near losses, the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, determine the root cause, and develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must use the Root Cause Analysis Flow Chart (Attachment 11) to assist in identifying the root cause(s) of a loss. Any loss may have one or more root causes and contributing factors. The root cause is the primary or immediate cause of the incident, while a contributing factor is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the person involved in the loss, his or her peers, or the supervisor should be referred to as "personal factors." Causes that pertain to the system within which the loss or injury occurred should be referred to as "job factors."

Personal Factors

- Lack of skill or knowledge
- Correct way takes more time and/or requires more effort
- Short-cutting standard procedures is positively reinforced or tolerated
- Person thinks there is no personal benefit to always doing the job according to standards

Job Factors

- Lack of or inadequate operational procedures or work standards
- Inadequate communication of expectations regarding procedures or standards
- Inadequate tools or equipment

The root cause(s) could be any one or a combination of these seven possibilities, or some other uncontrollable factor. In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates all seven other factors.

8.6 Corrective Actions

In the investigation report, include all corrective actions taken or those that should be taken to prevent recurrence of the incident. In addition, include the specific actions to be taken, the employer and personnel responsible for implementing the actions, and a timeframe for completion. Be sure the corrective actions address the causes.

Once the investigation report has been completed, the PM shall hold a review meeting to discuss the incident and provide recommendations. The responsible supervisors shall be assigned to carry out the recommendations, and shall inform the SSC upon successful implementation of all recommended actions.

8.7 Monthly Reports

The SSC will compile the information and prepare a report in accordance with Paragraph 01.D.05 (c), of the EM 385-1-1, which accurately reflects the employee-hours worked each month for all site workers, both prime and subcontractor. This report will be prepared on the form provided by the Contracting Officer's Representative (COR) and attached to the monthly billing request submitted to the COR.

9. Medical Support and Training

9.1 Personnel Qualified in First-aid and CPR

The following CH2M HILL individuals hold current certifications from the American Red Cross, American Heart Association, or other organization whose training is deemed equivalent.

- Glynn Roberts—Field Team Leader/SSC/QC Officer
- Tony Swierczek—QCSM
- TBD—Subcontractor

There will be a minimum of two staff on site at all times trained in first-aid/CPR and annual bloodborne pathogens training.

9.2 First-aid Kits

There will be at least one Type III first-aid kit available that meets the requirements of EM 385-1-1, paragraph 03.B.01 and Table 3-1, on each individual work site during hours of operation.

9.3 Emergency Medical Treatment

The procedures listed below may also be applied to nonemergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to HSM/Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the CSP/HSM. During non-emergencies, follow these procedures as appropriate:

- Get medical attention immediately by notifying the supervisor, SSC, or HSM.
- Prevent further injury.
- Initiate first-aid and CPR (if needed) where feasible.
- The SSC will assume charge during a medical emergency until the ambulance or emergency medical technician arrives or until the injured person is transported to the offsite medical facility.
- If the injured is a CH2M HILL employee, the SSC or PM must accompany the injured employee to the emergency room and to any follow-up appointments until the injured is released to full duty. Make certain that the injured person is accompanied to the emergency room.
- Report incident as outlined in Section 16, Incident Notification and Reporting.

9.4 Emergency Medical Support

In the event of an injury or illness requiring emergency medical attention the police, fire, and medical emergency dispatch will be immediately contacted by dialing 911.

All site workers participating in hazardous waste operations or emergency response will maintain an adequate medical surveillance program in accordance with 29 CFR 1910.120 or 29 CFR 1926.65 and other applicable OSHA standards. Documentation of employee medical qualification (for example, physician's written opinion) will be maintained in the project files and made available for inspection.

9.5 Hazardous Waste Operations and Emergency Response

CH2M HILL personnel expected to participate in onsite HAZWOPER are required to have a current medical qualification for performing this work. Medical qualification shall consist of a qualified physician's written opinion regarding fitness for duty at a hazardous waste site, including any recommended limitations on the

employee's assigned work. The physician's written opinion shall state whether the employee has any detected medical conditions that would place the employee at increased risk of material impairment of the employee's health from work in hazardous waste operations or emergency response, or from respirator use.

For the purposes of this SSHP, CH2M HILL employees are not expected to be involved in emergency response.

10. Personal Protective Equipment

(References: EM 385-1-1 Section 5, *Personal Protective and Safety Equipment*; CH2M HILL SOPs HSE-117, *Personal Protective Equipment*, and HSE-121, *Respiratory Protection*)

10.1 General Information

When actual or potential hazards exist and engineering controls or safe work practices cannot eliminate the hazard, employees shall use PPE. The employer shall provide field personnel with the required disposable and project-specific PPE and training.

Employees are responsible to:

- Acquire the necessary PPE from the employer.
- Complete the appropriate training to learn the proper use and care.
- Use PPE as required in the project-specific written safety plan.
- Inspect PPE prior to use and maintain it in a clean and safe condition.
- Refrain from modifying, tampering with, or repairing PPE beyond routine maintenance.
- Inform the employer of equipment that is damaged.
- Inform the employer of equipment that they believe does not adequately protect them from actual or potential hazards.

10.2 Hazard Assessment for Determining PPE Levels

The employer shall identify actual or potential hazards and the need for PPE. Two conditions typically dictate the necessity for PPE: general hazards present in the work area and hazards created by the tasks being performed. Some work areas have actual or potential hazards that can be present at any time, thereby potentially exposing any personnel working or walking through the area. Such areas should be posted as PPE-required areas, or personnel should be informed of the requirements in an equivalent manner. In addition, the actual task being performed may create a hazard and require personnel who perform this task to wear appropriate PPE. The areas where these tasks are taking place may become PPE-required areas as long as that specific task is taking place. The completed PPE Requirements per task assessment is reflected in Table 11-1. Specific hazardous assessments are conducted through the AHA process, and thus AHAs become the daily tool for proper hazard assessment and mitigation. The following table should be used as a general minimum guideline, with the specific task AHA having the final required protocol for PPE. AHAs are a living document, and should reflect changing site conditions.

See also the table in Section 2.76 for a more detailed hazard assessment for task. Basic minimum safety guidelines are further defined in Sections 12 and 13.

10.3 PPE Requirements

Personnel must comply with the PPE requirements as specified in Table 10-1.

TABLE 10-1
PPE Specifications/Requirements

Task	Level	Body	Head	Respirator [b]
General site uniform Site walkover Surveys Air/vapor sampling IDW Mgmt.	D[a]	**Coveralls:** Work clothes-long pants, shirt with at least a 3-inch sleeve. High visibility reflective vest while working around Heavy Equipment. **Boots:** ANSI Z41 approved steel-toe, leather work boots or equivalent. **Gloves:** Work glove while material handling.	ANSI Z89 approved hardhat[c] ANSI Z87 approved safety glasses with side shields. Hearing protection if necessary [d]	None required.
Monitoring Well Installation GW Sampling	Modified D[a]	Work clothes or cotton coveralls **Boots:** Safety-toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile and outer chemical-resistant nitrile gloves. Work Clothes or Coveralls. SC to determine body protection based on potential contact with site contaminants. If outer layer of personal clothing cannot be kept clean, then outer cotton coveralls or uncoated Tyvek coveralls shall be worn. (Polycoated Tyvek when there is potential to contact contaminated groundwater or free liquids from drums.)	ANSI Z89 approved hardhat [c] ANSI Z87 approved safety glasses with side shields. Hearing protection when within 50 feet of drill rig, with NRR of 27 dB [d]	None required.

[a] Modifications are as indicated. CH2M HILL will provide PPE to CH2M HILL employees only.

[b] No facial hair that would interfere with respirator fit is permitted.

[c] Hardhat and splash-shield areas are to be determined by the SSC.

[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet or less without shouting.

ANSI = American National Standards Institute

TABLE 10-2
Reasons for Upgrading or Downgrading Level of Protection

Upgrade [a]	Downgrade
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (see Section 15) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decrease the hazard. • Change in work task that will reduce contact with hazardous materials.

[a] Performing a task that requires an upgrade to a higher level of protection (for example, Level D to Level C) is permitted only when the PPE requirements have been approved by the HSM, and an SSC qualified at that level is present.

10.4 Training

CH2M HILL requires each PPE user to receive training on the proper care, maintenance, limitations, and instructions on how to wear and adjust PPE. The proper use of PPE should also be included in project safety briefings and toolbox meetings.

10.4.1 PPE Certification

I certify that the PPE requirements listed in the table above for the associated tasks are based upon the project-specific hazard assessment I performed.

Mark Orman, CSP	11/12/2012	11/12/2012
Name	Date of Certification	Date(s) of Project Hazard Assessment

11. Plans Required by the Safety Manual

11.1 Emergency Response Plans

11.1.1 Emergency Preparedness Training

The emergency response plan and contacts is in Attachment 4 and will be reviewed during the initial arrival to the jobsite and occasionally during site safety briefings. The briefings should include:

- Emergency procedures for fires, explosions, chemical and vapor releases, personnel injuries, and suspected overexposure as they apply to the site
- Location of onsite emergency equipment and supplies of clean water
- Local emergency contacts, evacuation routes, and assembly points
- Site communication and location of phone and radio nearest
- Names of onsite personnel trained in first-aid and CPR

11.1.1.1 Emergency Equipment and Supplies

The SSC will verify that these supplies are available, as needed, and in proper working order, and mark the locations of emergency equipment on the site map when a map is provided.

TABLE 11-1
Emergency Equipment and Supplies

Emergency Equipment and Supplies	Location
2 fire extinguishers (A, B, and C classes)	Field vehicle
First-aid kit	Field vehicle
Eye wash	Field vehicle
Potable water	Field vehicle
Bloodborne pathogen kit	Field vehicle
Additional equipment (specify):cell phone	SSC

11.1.1.2 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Shut down operations and evacuate the immediate area.
- Notify the SSC and PM by the fastest means available.
- Account for personnel at the designated assembly area(s).
- Assess the need for site evacuation, and evacuate the site as warranted.
- Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled.

11.1.1.3 Emergency Medical Treatment

The procedures listed below may also be applied to non-emergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to CH2M HILL HSM/Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical

treatment, contact the CH2M HILL medical consultant (see Emergency Contacts List in Attachment 4). During non-emergencies, follow these procedures as appropriate.

- Notify appropriate emergency response authorities. **Contact the police, fire, and medical emergency dispatch by** 911.
- The SSC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first-aid and CPR (if needed) where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible; lifesaving and first-aid or medical treatment take priority.
- Make certain that the injured person is accompanied to the emergency room.
- When contacting the medical consultant, state that the situation is a CH2M HILL matter, and give your name and telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.

11.1.1.4 Evacuation Procedures

- Evacuation routes and assembly areas will be designated by the SSC before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if safe) to inform local responders of the nature and location of the incident.
- Each supervisor will account for their personnel at the assembly area, and report to the PM or CSP/HSM that either all personnel are accounted for, or the number of personnel unaccounted for.
- The SSC will write up the incident as soon as possible after it occurs and submit a report to the PM and/or CSP/HSM.

Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

11.2 Spill Plans

In the event that any hazardous materials are spilled, the onsite employees will take immediate action to prevent further release as appropriate by turning off the source, uprighting the container, or other immediate actions that can be safely performed.

Employees will only perform defensive actions to prevent further spread or release. Defensive actions are actions that can be performed without actual contact with the released materials and without the use of additional levels of PPE protection. These actions include, but are not limited to the following:

- Turning off a nozzle or valve
- Uprighting a knocked over container

- Applying loose sorbent materials to a spill
- Placing sorbent booms or pads around the spilled materials to prevent further spread

Employees will immediately notify the SSC, who will notify the CSP/HSM, as to the location of the spill and any defensive measures taken to reduce its impact of further release.

Employees who have come into contact with any spilled hazardous materials will immediately seek emergency decontamination. Emergency decontamination includes the following actions:

- Remove any contaminated clothing.
- Immediately drench affected body areas with water.
- Seek medical attention as required.
- Maintain sorbent material in the support zone. Incidental spills will be contained with sorbent and disposed of properly.
- Plastic sheeting shall be considered IDW for disposal purposes.

All spills will be reported to the client, PM and CSP/HSM as required.

Spills of hazardous materials will be cleaned up, containerized, and disposed of in compliance with the local city/state/municipality directives.

11.3 Site Control Plan/Site Control Procedures

(Reference CH2M HILL SOP HSE-510, *Site Control)*

- The SSC will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing onsite safety: general discussion of the SSHP, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures pertaining to emergencies.
- The SSC records attendance at safety briefings in a logbook and documents the topics discussed.
- Post the OSHA jobsite poster in a central and conspicuous location in accordance with CH2M HILL, OSHA Postings. (Not Required)
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals
  - Air horn
  - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the “buddy system.”
- Initial air monitoring is conducted by the SSC in appropriate level of protection.
- The SSC is to conduct periodic inspections of work practices to determine the effectiveness of these procedures. Deficiencies are to be noted, reported to the HSM, and corrected.

An exclusion zone (size TBD pending site configuration) will be maintained around work areas where sampling activities are occurring or with any activity where chemical materials may be encountered. Protective clothing and equipment are to be worn by any personnel working within the exclusion zone. At a minimum, Level D PPE is required. The purpose of the exclusion zone is to limit outside personnel from entering the work area and potentially injuring themselves or exposing themselves to hazardous work conditions or chemicals. The exclusion zone will include a limited access ingress and egress for personnel and equipment. The zone is to be

demarcated with caution/hazard tape and barricades (or similar restricting material). The exclusion zone is to be clearly labeled as such. All personnel are required to log in/out of exclusion zones daily.

11.3.1 Decontamination

(Reference CH2M HILL SOP HSE-506, *Decontamination*)

(Reference CH2M HILL SOP HSE-218, *Hazardous Waste Operations*)

The SSC must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SSC. The SSC must ensure that procedures are established for disposing of materials generated on the site. All rinse waters and materials shall be contained, and shall be disposed of according to client and/or site protocols.

11.3.1.1 Decontamination Specifications

Personnel	Sample Equipment	Heavy Equipment
• Boot wash/rinse • Glove wash/rinse • Outer-glove removal • Body-suit removal • Inner-glove removal • Respirator removal • Hand wash/rinse • Face wash/rinse • Shower ASAP • Dispose of PPE in municipal trash, or contain for disposal • Dispose of personnel rinse water to facility or sanitary sewer, or contain for offsite disposal	• Wash/rinse equipment • Solvent-rinse equipment • Contain solvent waste for offsite disposal	• Power wash • Steam clean • Dispose of equipment rinse water to facility or sanitary sewer, or contain for offsite disposal

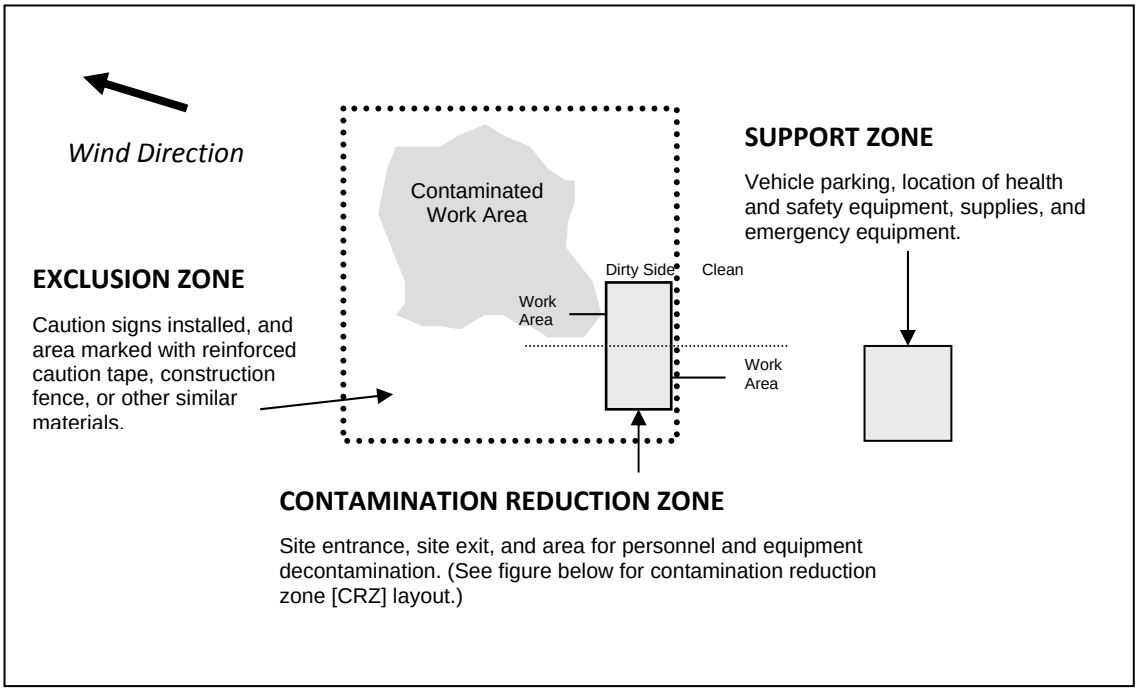
11.3.1.2 Diagram of Personnel-Decontamination Line

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SSC should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

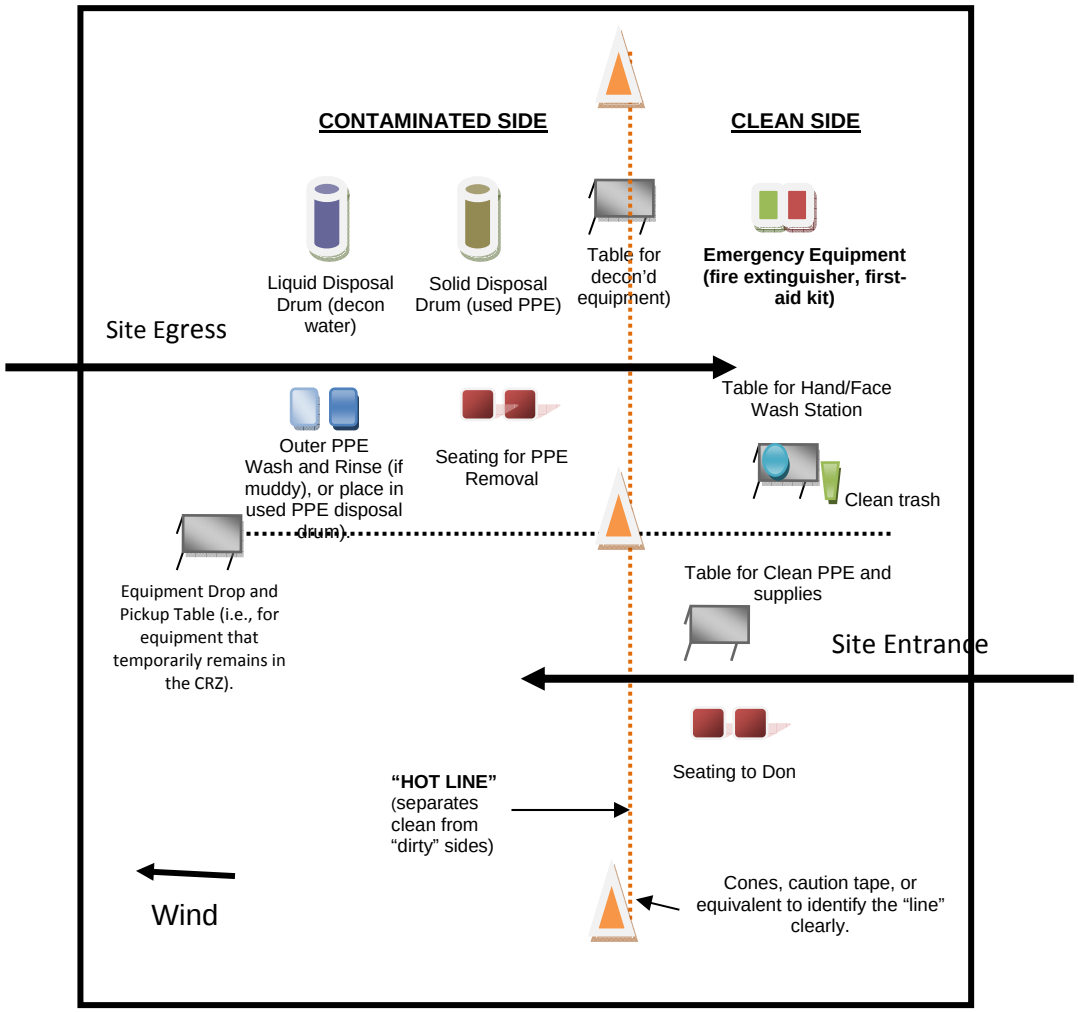
The following figure illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SSC to accommodate task-specific requirements.

No smoking is permitted in the work area. The SSC should establish areas for eating, drinking, and smoking.

Work Area - Set up appropriately based on wind direction.



Typical Contamination Reduction Zone



11.3.2 Firefighting Plan

(References: Section 01.E.01 & 06.A.02, EM 385-1-1 and CH2M HILL SOP HSE-208, *Fire Prevention*)

The decision on whether or not to try to extinguish a fire using available site personnel and equipment will be made by the SSC, and is based on whether the fire is small or large, and involves explosives or flammable liquids/gases.

11.3.2.1 Location of Fire Extinguishers

Fire extinguishers will be located around the project sites as required. These will be located in the following places at a minimum:

- In each vehicle
- Near areas where flammable materials are stored or in use

All fire extinguishers will be kept clearly visible, marked, and placed where they are easily accessible.

11.4 Hazard Communication Program

(References: Section 01.B.06, EM 385-1-1 and CH2M HILL SOP HSE-107, *Hazard Communication*)

- Effective information and training on hazardous chemicals shall be given to project employees by their employer at the time of initial assignment and/or whenever a new physical or health hazard the employees have not been previously trained about is introduced into their work area.
- All onsite hazardous chemicals shall have an accompanying Material Safety Data Sheet (MSDS) available to employees for reference.
- The subcontractor shall submit a copy of the MSDS sheet to the SSC for all onsite hazardous chemicals and when a new hazardous chemical is introduced to the project.
- The SSC will complete the Chemical Specific Training Form, included in Attachment 3, to verify that training is provided on the hazards associated with these chemicals and the control measures to be used to prevent exposure to personnel are implemented.
- The subcontractor shall provide documentation (see the Chemical-Specific Training Form in Attachment 3 for an example) to the SSC to verify that they have provided adequate employee training for the onsite hazardous chemicals.
- All chemical containers shall be labeled with the identity of the chemical and with hazard warnings.

All hazardous materials will be properly stored. The SSC will give consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

11.4.1 HAZWOPER Compliance Plan

(Reference CH2M HILL, SOP HSE-220, *Written Plans)*

This SSHP complies with a HAZWOPER program and requires staff to comply with hazardous waste operations or emergency response as required by 29 CFR 1910.120 and 29 CFR 1926.65.

11.5 Respiratory Protection Program

(References: Section 05.E.03, EM 385-1-1 and CH2M HILL SOP HSE-121, R*espiratory Protection*)

Not required.

11.6 Health Hazard Control Program

(Reference: EM 385-1-1 Section 01.B.06)

The Health Hazard Control Program will be conducted by the use of the Activity Hazard Analysis process. This section outlines the process that will be used by the SSC onsite to determine the presence of hazardous environments or whether hazardous or toxic agents could be released into the work environment.

11.6.1 General Information

AHAs shall be developed during the preparation stage for each definable work task. An AHA is a procedure that integrates accepted health and safety principles and practices into a particular operation. In an AHA, each basic step of the overall task is examined to identify potential hazards and to determine the safest way to do the job.

Four basic stages in conducting an AHA are as follows:

- Selecting the task to be analyzed
- Breaking the task down into a sequence of steps
- Identifying potential hazards
- Determining preventive measures to overcome these hazards

AHAs are intended to be a starting point and must be reviewed (and modified as appropriate) by the entire work team prior to initially conducting the task.

The AHA process will identify previously undetected hazards and increase the job knowledge of those participating. Safety and health awareness is raised, communication between workers and supervisors is improved, and acceptance of safe work procedures is promoted. The completed AHA will be the basis for regular contact between supervisors and workers on health and safety. It will serve as a teaching aid for initial job training. The AHA will also be used as a standard for health and safety observations and assist in completing comprehensive accident investigations.

All AHAs will be documented, reviewed, and signed by the SSC, Site Supervisor, and all workers involved in the task. All AHAs will be maintained onsite by the SSC.

11.6.2 Tasks Requiring Activity Hazard Analyses

AHAs are required for all definable work tasks. As the project gets closer to initiation of field operations, additional information such as identification of subcontractor, specific equipment and/or tools is obtained, the AHAs will be updated accordingly. The planned field tasks requiring AHAs are as follows:

- 01 Building surveys and chemical inventories
- 02 Subslab soil gas, indoor and outdoor air sampling
- 03 Monitoring well installation
- 04 Groundwater sampling
- Investigation-derived waste (IDW) management

The project AHAs for the hazardous work operations listed above are included in Attachment 8, Detailed Activity Hazard Analysis Procedures.

To complete a detailed AHA form, the responsible supervisor obtains an AHA form (an example is given in Attachment 8) and identifies individuals who will be performing the task. With the assistance of those employees performing the task, the responsible supervisor should:

- Define the task and describe the work activity, including the tools, equipment, materials, and personnel to perform the activity.
- Identify the sequence of work or principal steps that are required to perform the activity.
- Identify and analyze the chemical, physical, safety, and biological/environmental hazards posed by each step in the activity.

- Identify the main hazard control measures for each hazard identified—hazard control measures shall follow the hierarchy of (1) implementing engineering control, (2) instituting safe work practices, and (3) providing PPE.
- List equipment, tools, and materials that will be used to perform the activity, along with the equipment/tool inspection and training requirements for workers and supervisors.
- Ensure employees have training qualifications necessary to perform their assigned duties and job functions.
- Identify and summarize relevant SOPs, as part of the hazard control measure identified for each work task.
- Review the AHA form in a safety briefing with all project personnel who will be performing the task prior to task performance (ensure that their signature is on the AHA form).
- Brief any new members to the crew prior to performing the task.
- Verify that the control measures recommended are implemented during execution of the work by assigning responsibilities to the appropriate team members.

The responsible supervisor must review all AHAs with all project personnel who will be performing the task in a safety briefing, prior to task performance. Any new crew members shall be briefed on the AHA prior to performing the activity. In addition, the responsible supervisor shall oversee subcontractor implementation of this AHA process for their work.

11.6.3 Activity Hazard Analysis Planning Tools

The following are planning tools that shall be used when preparing detailed AHAs.

11.6.3.1 Activity/Task Hazard Analysis Table

The Task Hazard Analysis Table, Section 2.6, details potential health and safety hazards for each project phase or task. Relevant safety procedures must be reviewed to identify the applicable hazard control procedures in the AHA.

11.6.3.2 Subcontractor Activity-specific Safety Procedures

Subcontractor Activity-Specific Safety Procedures are not intended to be all-inclusive, but are provided as a tool to facilitate development and review of safe work procedures. Subcontractors are expected to address each outlined criterion as part of their AHA planning.

11.6.3.3 Project Activity Self-assessment Checklists

Project Activity Self-Assessment Checklists, Attachment 5, have been provided as a method of verifying compliance with established safe work practices, regulations, and industry standards pertaining to various activities. Project activity self-assessments shall be performed at the start of specific hazardous work activity, then at least weekly and at intervals appropriate for the nature of work site activities. Checklists provided in Attachment 5 are for CH2M HILL employee use only. Each subcontractor shall provide their own checklists to be used to assess the adequacy of site-specific safety requirements and determine whether control measures identified in the AHA are adequate for each work task.

11.6.4 Pre-task Safety Planning

Pre-task Safety Planning (PTSP) ensures that daily tasks are performed with safety integrated into the daily work routine. PTSP requires that the team identify that day's tasks to be performed; required equipment, tools, and materials to perform these tasks; the potential hazards posed; and required HS&E procedures.

A PTSP Form, Attachment 9, shall be completed for each work crew performing field activities. The PTSP shall be completed before work begins each morning throughout the course of the project. The supervisor/foreman

and their crew complete the PTSP. The supervisor/foreman reviews the PTSP with each crew member during that day's safety briefing, using the following process:

- List all task personnel and the tasks that will be performed by the work crew for the workday.
- Review the overall task planning outlined in the AHA for this activity.
- List the tools and equipment required for that day's tasks.
- Identify and check the potential health and safety hazards posed by that day's tasks on the PTSP.
- Identify and check the hazard control procedures that will be employed to control the identified health and safety hazards posed by that day's tasks on the PTSP.
- Provide appropriate site-specific training to ensure employees can perform their job in a safe manner.
- Keep the PTSP in the work area, revise it, and brief the work crew when additional tasks are to be performed or when unanticipated hazards are encountered that were not listed on that day's PTSP.
- Monitor work crew compliance with the hazard control measures listed in the PTSP.
- Each work crew's daily PTSP shall be signed by the crew members and the supervisor/foreman. The supervisor/foreman shall submit the PTSP to the HSM at the end of the workday for review

The SSC shall review each work crew's daily PTSP, confirm that the potential health and safety hazards and control measures are identified for the listed tasks in that day's PTSP, and maintain them as part of the onsite project files to document compliance with this process.

11.7 Contingency Plan for Severe Weather

11.7.1 Inclement Weather

- Work may proceed in light rain—wear rain gear. However, no roof work can proceed during any storm event!
- Exposure to slips, trips, and falls is increased during rainy conditions.
- Take cover in a sheltered location during adverse weather conditions (high winds, heavy rain).
  - Work shall cease and cover shall be taken in the event of lightning or tornado warnings.
  - Identify "Take Shelter" areas before starting the project.
- Notify the PM after shelter has been sought.

Adverse weather conditions requiring immediate suspension of field work activities are defined as the following:

- Thunder or lightning. Thunderstorm watches or warning, as the situation warrants, will be used as an alert to potential electrical activity. Typically, a 30-minute standdown occurs to allow the storm cell to pass the area. If lightning or thunder is observed within the standdown period, the 30-minute time frame is extended until electrical activity ceases.
- Sustained wind gusts of 25 mph for boating activities.
- Sustained wind speeds of 25 mph or wind gusts of 35 mph for high-profile work where wind chill is not a factor, that is, greater than 60°F.
- Sustained wind speeds of 40 mph or wind gusts of 45 mph for non-high-profile work.
- Moderate rain and/or snow fall of 0.11 to 0.3 inch per hour during hoisting activities. Freezing rain is also cause for suspending hoist use.
- An equivalent wind chill factor of -24°F on the wind chill factor chart (see Section 13.2.5) will trigger systematic shut down of all non-emergency work activities.
- A tornado or hurricane warning for the general area or county will suffice in requiring a general work stoppage.

- If you are inadvertently caught outside in a thunder/lightning storm, take the following precaution:
  - Move away from all metal structures.

11.8 Prevention of Alcohol and Drug Abuse

*(*References: DFARS, Subpart 252.223-7004 and CH2M HILL SOP HSE-105, *Drug Free Workplace Program)*

11.8.1 Drug-free Workplace

CH2M HILL does not tolerate illegal drugs, or any use of drugs, controlled substances, or alcohol that impairs an employee's work performance or behavior. CH2M HILL has established a policy that its employees and subcontractors shall not be involved in any manner with the unlawful manufacture, distribution, dispensation, possession, sale, or use of illegal drugs in the workplace. The use or possession of alcohol in the workplace is also prohibited. Any violation of these prohibitions may result in discipline or immediate discharge. Please reference CH2M HILL SOP HSE-105, *Drug-Free Workplace Standard of Practice*, for more information. The following sections describe mandatory program requirements.

11.8.2 Policy Statement

A policy statement is included in the corporate Drug-Free Workplace Program. This policy statement details prohibited conduct and ramifications, and:

- Prohibits drug, alcohol, and/or controlled substances use or abuse.
- Prohibits involvement in the manufacture, distribution, dispensation, possession, sale, or use of illegal drugs in the workplace.
- Describes disciplinary actions that may be taken.

11.8.3 Subcontractor Management

The subcontractor must comply with the provisions of this program. As a minimum the subcontractor must provide a written statement that their drug-free workplace program meets the minimum requirements outlined in CH2M HILL's program.

The prime contractor PM and SSC can request to be provided copies of any subcontractors employees last negative screening results. These results cannot be over 12 months old.

It is the responsibility of subcontractors to transfer this plan to the lower-tiered subcontractors.

11.8.4 Prescription and Nonprescription Drugs

Employees using prescription or nonprescription drugs that could impair their functions on the project are required to notify the employer in advance of such drug use.

Failure to report prescription and nonprescription drugs as required above, illegally obtaining the substance, or use that is inconsistent with the prescription or label may be subject to disciplinary action.

The subcontractor is required to document that all of their employees have also been provided with a drug-free workplace and alcohol education program.

11.9 Fire Prevention Plan

(References: EM 385-1-1 Section 09.A.01, and CH2M HILL SOP HSE-208, *Fire Prevention*)

- A fire extinguisher, rated not less than 2A, shall be provided for each 280 square meters of a combustible building area, or major fraction thereof. Travel distance from any point of the protection area to the nearest fire extinguisher shall not exceed a horizontal distance of 50 feet or 15 meters.

- When 10 liters or more of a flammable or combustible liquid is being used, an extinguisher must be within 15 meters.
- Extinguishers must:
  - Be maintained in a fully charged and operable condition.
  - Be visually inspected each month.
  - Undergo a maintenance check and certification each year.
- The area in front of fire extinguishers must be kept clear.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

Fire extinguishers can represent an important segment of any overall fire protection program. However, their successful functioning depends upon the following conditions having been met:

- The extinguisher is properly located and in working order.
- The extinguisher is of proper type and for a fire which may occur.
- The fire is discovered while still small enough for the extinguisher to be effective.
- The fire is discovered by a person ready, willing, and able to use the extinguisher.
- Class C fires (see below for fire classifications) can be readily extinguished by quenching-cooling with water or a water-mixture agent. Class B fires are more effectively extinguished by an agent that blankets-smothers the fire through exclusion of oxygen surrounding the fire area. Those extinguishers containing bromochlorodifluoromethane, monobromotrifluoromethane, carbon dioxide, or dry chemical are generally best suited for extinguishing Class B fires. For Class C fires, the primary consideration in extinguishing this type of fire is the selection of nonconductive extinguishing agent to prevent dangerous electrical shock and possible death to user.
- Due to its corrosive nature, dry chemical is not recommended for use on computerized, electronic, or other equipment with extensive circuitry.
- The following chart defines/explains classes of fires:

A		Common Combustibles	Wood, paper, cloth etc.
B		Flammable liquids and gases	Gasoline, propane and solvents
C		Live electrical equipment	Computers, fax machines (see note!)
D		Combustible metals	Magnesium, lithium, titanium
K		Cooking media	Cooking oils and fats

Fires are classified into five groups:

- Class A: Class A fires involve common combustibles such as wood, paper, cloth, rubber, trash and plastics. They are common in typical commercial and home settings, but can occur anywhere these types of materials are found.

- Class B: Class B fires involve flammable liquids, gases, solvents, oil, gasoline, paint, lacquers, tars and other synthetic or oil-based products. Class B fires often spread rapidly and, unless properly secured, can re-flash after the flames are extinguished.
- Class C: Class C fires involve energized electrical equipment, such as wiring, controls, motors, data processing panels or appliances. They can be caused by a spark, power surge or short circuit and typically occur in locations that are difficult to reach and see.
- Class D: Class D fires involve combustible metals such as magnesium and sodium. Combustible metal fires are unique industrial hazards which require special dry powder agents.

(NOTE: Although ABC and BC dry chemical extinguishers can control a fire involving electronic equipment, the National Fire Code specifically advises against dry-chemical extinguishers for fires involving computers or other delicate electronic equipment due to the potential damage from residues.)

Firefighting shall only be conducted by those trained and certified in this practice. The commonly accepted practice is the PASS method. This means, pull the pin, aim, squeeze the handle and sweep the base of the fire area. The SSC shall verify that at least two staff are on site that have the required training for use of Fire Extinguishers.

11.10 Site Sanitation Plan

Housekeeping: all work areas shall be maintained free and clear of clutter, tools and debris that may pose a trip, slip, or fall hazard to staff. Each work area shall be evaluated prior to work starting in that location.

Restrooms and drinking water are available onsite or at nearby gas stations and/or restaurants. Proper industrial hygiene practices shall be conducted on this site.

This program will comply with EM-383-1-1 Sept 2008, Section 02 of the manual.

11.11 Confined Space Entry Activities

(Reference CH2M HILL, SOP HSE-203, *Confined Space Entry*)

A confined space is defined as a space that has all of the following characteristics:

- Large enough to allow personnel to enter the space with their entire body;
- Limited openings for entry and exit; and
- Not designed for continuous human occupancy;

Examples of possible confined spaces include underground vaults, pipelines, ducts, tunnels, storage tanks, sewers, process vessels, and pits. Entry into a confined space is defined as breaking the plane of a confined space with any part of the body.

The following requirements apply when entering a permit-required confined space (PRCS), an Alternate Procedure Confined Space, or a PRCS reclassified as a non-permit confined space (NCS). Ensure the requirements in the referenced SOP are followed.

- Entrants, Attendants, and the Entry Supervisor shall have successfully completed Confined Space Entry training.
- The appropriate confined space entry permit shall be completed as outlined in CH2M HILL SOP HSE-203, *Confined Space Entry*.
- The completed permit or certificate shall be posted for review near the space entrance point.
- The Entry Supervisor shall conduct a pre-entry briefing with all Authorized Entrants and Attendants prior to entry in accordance with SOP HSE-203.

- Entrants and Attendants shall verify that the Entry Supervisor has authorized entry and that all requirements of the permit or certificate have been satisfied prior to each entry.
- Atmospheric monitoring for oxygen, combustible gases, and potential toxic air contaminants shall be conducted at the frequency provided on the permit or certificate. Entry shall not be permitted if an atmospheric hazard is detected above acceptable safe levels. Atmospheric monitoring shall be performed in accordance with the Site Monitoring Section of the project safety plan and SOP HSE-203.
- Entrants shall evacuate the space upon orders of the Attendant or Entry Supervisor, when an alarm is sounded, or when a prohibited condition or dangerous situation is recognized.
- Entrants and Attendants shall inform the Entry Supervisor of any hazards confronted or created in the space, or any problems encountered during entry. The Entry Supervisor shall inform the owner of such issues.
- The Entry Supervisor shall provide a copy of the canceled permit or certificate to the SC for review and maintain it in the project file.
- Complete the self-assessment checklist for confined space entry whenever entries are being performed.

12. Contractor Information/Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the SSC for clarification.

In addition to the controls specified in this section, Project-Activity Self-Assessment Checklists are contained in Attachment 5. These checklists are to be used to assess the adequacy of CH2M HILL and subcontractor site-specific safety requirements. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. Self-assessment checklists should be completed early in the project, when tasks or conditions change, or when otherwise specified by the HSM. The self-assessment checklists, including documented corrective actions, should be made part of the permanent project records, and be promptly submitted to the HSM.

12.1 Project-Specific Physical (Safety) Hazards

12.1.1 Field Vehicles

- Ensure a rental car meets the following requirements:
  - Dual air bags
  - Antilock brakes
  - Midsize or larger
- Familiarize yourself with rental vehicle features:
  - Mirror adjustments
  - Seat adjustments
  - Cruise control features, if offered
  - Preprogram radio stations
- Always wear the seatbelt while operating the vehicle.
- Adjust the headrest to proper position.
- Tie down loose items if using a van.
- Pull off the road, put the car in park, and turn on flashers before talking on a mobile phone.
- Maintain both a first-aid kit and fire extinguisher in the field vehicle at all times.
- Close car doors slowly and carefully. Fingers can get pinched in doors or the trunk.
- Take shelter in the field vehicle in the event of heavy rain.
- Listen to car radio for predictions of tornado or lightning.
- Park vehicle in a location where it can be accessed easily in the event of an emergency.

12.1.2 Cell Phones

Cell phones, earpieces, and/or headphones shall not be used while operating company vehicles, rental vehicles, or personal vehicles for company business, including traveling to/from the project site.

Cell phones can be used in designated safe zones, away from operating equipment. Cell phones shall also be used for emergency support operations.

Key personnel cell numbers are listed in Attachment 4 under emergency contacts.

12.1.3 Hand and Power Tools

(Reference CH2M HILL SOP HSE-210, *Hand and Power Tools*)

- The employee is responsible for complying with all applicable HS&E training requirements relating to hand and power tool safety and for providing any additional training necessary to complete their tasks safely.
- Operate all tools according to the manufacturer's instructions and within design limitations.
- All hand and power tools shall be maintained in a safe condition.
- Tools are to be inspected and tested before use—if a tool is found to be defective it is to be tagged "Do Not Use" and removed from service until repaired.
- Personal protective equipment, such as gloves, safety glasses, earplugs, and face shields, are to be used when exposed to a hazard from the tool (see Section 11, Personal Protective Equipment).
- Power tools are not to be carried or lowered by the cord or hose.
- Disconnect tools from energy sources when not in use, before servicing and cleaning, and when changing accessories such as blades, bits, and cutters.
- Safety guards on tools are to remain installed while the tool is in use and promptly replaced after repair or maintenance has been performed.
- Tools are to be stored properly, where they will not be damaged or come in contact with hazardous materials.
- If a cordless tool is connected to its recharge unit, both pieces of equipment must conform strictly with electrical standards and manufacturer's specifications.
- Tools used in an explosive environment must be rated (that is, intrinsically safe, spark proof, etc.) for work in that environment.
- When using a knife or blade tool, stroke or cut away from the body with a smooth motion taking care not use excessive force that could damage tool, material being cut, or unprotected hands.
- As alternatives to manual and pistol-grip hand tools that involve work with highly repetitive movement, extended elevation, constrained postures, or positioning of body members (for example, hand, wrist, arm, shoulder, neck, etc.):
  - Consider alternative tool design
  - Improve posture
  - Select appropriate materials
  - Organize work—sequencing to prevent muscular skeletal, repetitive motion, and cumulative trauma stressors
- Only employees who have been trained in the operation of the particular tool in use shall be allowed to operate a powder-actuated tool—training and certification must be provided to the SSC before using the tool.
- Ground fault circuit interrupters (GFCI) protection shall be used on all electrical tools within the vicinity of water.

12.2 Personal Security

Follow the guidelines below for personal security measures. The responsible health and safety manager (RHSM) and Firm-Wide Security Office can be contacted if additional, specific measures are needed (e.g., such as evaluating the needs for security service).

12.2.1 General Safety and Security Guidelines

CH2M HILL Corporate Security Department recommends the following guidelines for workers in the United States:

- Stay alert and be aware of your surroundings. Avoid pre-occupations with mobile devices, while in an unfamiliar area.

- Whenever possible use the buddy system with another employee or client or subcontractor employee.
- Trust your intuition; if a situation appears strange or wrong, it probably is.
- Be confident in your walk or stride; do not give the appearance you are new in town.
- Avoid carrying and displaying large sums of cash.
- If you sense or see dangerous situations along your route, change your route and depart the area quickly. If you feel that you are being followed, go to the nearest police station or safe location and file a complaint with the police. Provide a description of the person, their vehicle, license plate number, and any other useful information.
- Only walk short distances that are safe and secure while visiting an unfamiliar city or location.
- Take host approved transportation for long distances.
- “Fight or Flight?” Leaving the possible or dangerous area is always better than staying to fight.
- Always report suspicious activity to the nearest local law enforcement agency.
- Locate emergency exits in your hotel or where you are staying to ensure you know where to go in case of a fire or a natural or manmade disaster.
- Secure your electronic devices when left in your room or take them with you if you are not able to secure them properly.
- If you feel your life is in danger, call 911. Be sure to speak clearly, concisely and give the dispatcher a good description of where you are physically located.

12.2.2 Operating or Riding in Vehicles

- When waiting for public transportation or a taxi, remain in a store or restaurant as long as possible before catching your ride and never wait by yourself in an isolated area.
- Approach your vehicle with keys firmly in your hand and ready to unlock the car.
- Quickly check your car before entering it to determine damage or presence of an intruder.
- Vulnerable times can be stopping to find your keys to enter your vehicle or stepping out of your vehicle in an isolated area. Be aware of your surroundings before you perform these activities.
- Always keep your doors locked during transit and when the vehicle is parked.
- Never leave your vehicle unlocked, even when performing a quick task such as checking in at a hotel, getting gas, or picking up food.
- If confronted by an individual inside a vehicle pointing a weapon at you, run the opposite way from where the vehicle is facing and scream as loud as you can. This evasive action will probably cause the individual to drive away.
- If an individual in a passing car points at your tires or engine to indicate a malfunction, only pull over in a well-lit and populated gas or rest stop. Never pull over in an isolated or dimly lit area. You may have a malfunction or the passing motorist may be attempting to rob you.
- Always park your vehicle is a well-lit and secure area. If your vehicle is parked in a dimly lit or isolated area in a parking garage; ask an attendant or friend to accompany you to your vehicle.
- Secure your valuables in the trunk, or place them out of sight or cover them with a blanket or coat if there is no secure storage area in the vehicle. The would-be-perpetrator likes to see what to steal and not knowing what you have concealed will normally prevent a break in.

12.2.3 Riding in a Taxi

- Have your host or a designated travel agent suggest or reserve a reputable taxi service for you during your stay.
- Only use a taxi service that was vetted for safety and reliability.
- If possible, place luggage, laptop and personal belongings inside the taxi.
- When you first enter the taxi, check the driver photo identification card, normally located on the driver's visor with the driver to ensure they match.

12.2.4 Walking

- If you experience automotive trouble, remain inside the locked vehicle and call for assistance.
- If you can't reach assistance via a mobile phone, only walk for help in a safe area facing the traffic.
- If while walking, you are shadowed or followed by a vehicle, run back in the direction of your vehicle and enter the vehicle if possible. File a police report on the incident as soon as practicable.
- Be aware of your surroundings and those around you while walking and do not be distracted by using electronic devices.
- Regularly change your route if you are walking to and from meetings or conferences and choose only well-lit areas to walk in at night.
- If walking long distances, identify a "safe house, shop, store or restaurant" to duck into if confronted by a perpetrator.

12.2.5 Jogging or Running

- Always jog or run in an area that is safe, secure, and used for exercising.
- Avoid running along busy roads or highways.
- If you chose to venture out on a jog or run, check the route by vehicle prior to beginning to exercise.
- Let the host or a friend know when you leave, when you plan to return, and the route you will take during exercising.
- Take a photo identification and mobile phone with you for emergencies.
- Avoid physically over-extending yourself since reflexes and decision making ability can be impaired.

12.2.6 Clothing and Jewelry

- Dress to blend in with locals, maintain a low profile, and avoid drawing attention to yourself.
- Travel with inexpensive clothing and jewelry.
- Avoid wearing CH2M HILL distinctive clothing or using CH2M HILL logos on luggage or laptops.

12.2.7 Emergency Numbers and Information

- Leave your itinerary and emergency contact numbers where you can be reached with family members and only those that have a need to know.
- Pre-program emergency numbers in the mobile device you are traveling with.
- Carry a list of current medications and specific doses in your purse or wallet.
- Record medical emergency information on a document that can be readily available if you are unable to speak or unconscious.
- Have a photocopy of your driver's license, passport, and credit card information separately in case your wallet or purse is stolen.

12.3 Utilities (underground)

An assessment for underground utilities must be conducted where there is a potential to contact underground utilities or similar subsurface obstructions during intrusive activities. Intrusive activities include excavation, trenching, drilling, hand augering, soil sampling, or similar activities.

The assessment must be conducted before any intrusive subsurface activity and must include at least the following elements:

- A background and records assessment of known utilities or other subsurface obstructions.
- Contacting and using the designated local utility locating service.
- Conducting an independent field survey to identify, locate, and mark potential underground utilities or subsurface obstructions. *Note: This is independent of, and in addition to, any utility survey conducted by the designated local utility locating service above.*
- A visual survey of the area to validate the chosen location.
- When any of these steps identifies an underground utility within 5 feet (1.5 meters) of intrusive work, then non-aggressive means must be used to physically locate the utility before a drill rig, backhoe, excavator or other aggressive method is used.
- Aggressive methods are never allowed within 2 feet of an identified high risk utility (see paragraph below).
- Any deviation from these requirements must be approved by the Responsible HS Manager and the Project Manager.

12.3.1 Background and Records Assessment of Known Utilities

Identify any client- or location-specific permit and/or procedural requirements (e.g., dig permit or intrusive work permit) for subsurface activities. For military installations, contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Obtain available utility diagrams and/or as-built drawings for the facility.

Review locations of possible subsurface utilities including sanitary and storm sewers, electrical lines, water supply lines, natural gas lines, fuel tanks and lines, communication lines, lighting protection systems, etc. Note: Use caution in relying on as-built drawings as they are rarely 100 percent accurate.

Request that a facility contact with knowledge of utility locations review and approve proposed locations of intrusive work.

12.3.2 Designated Local Utility Locating Service

Contact your designated local utility locating service (e.g., Dig-Safe, Blue Stake, One Call) to identify and mark the location of utilities. Call 811 in the U.S. or go to www.call811.com to identify the appropriate local service group. Contacting the local utility locating service is a legal requirement in most jurisdictions.

12.3.3 Independent Field Survey (Utility Locate)

The organization conducting the intrusive work (CH2M HILL or subcontractor) shall arrange for an independent field survey to identify, locate, and mark any potential subsurface utilities in the work area. This survey is in addition to any utility survey conducted by the designated local utility locating service.

The independent field survey provider shall determine the most appropriate instrumentation/technique or combinations of instrumentation/techniques to identify subsurface utilities based on their experience and expertise, types of utilities anticipated to be present, and specific site conditions.

A CH2M HILL or subcontractor representative must be present during the independent field survey to observe the utility locate and verify that the work area and utilities have been properly identified and marked. If there

is any question that the survey was not performed adequately or the individual was not qualified, then arrangements must be made to obtain a qualified utility locate service to re-survey the area. Obtain documentation of the survey and clearances in writing and signed by the party conducting the clearance. Maintain all documentation in the project file.

If the site owner (military installation or client) can provide the independent field survey, CH2M HILL or the subcontractor shall ensure that the survey includes:

- Physically walking the area to verify the work location and identify, locate, and mark underground utility locations.
- Having qualified staff available and instrumentation to conduct the survey.
- Agreeing to document the survey and clearances in writing.
- Should any of the above criteria not be met, CH2M HILL or subcontractor must arrange for an alternate independent utility locate service to perform the survey.
- The markings from utility surveys must be protected and preserved until the markings are no longer required. If the utility location markings are destroyed or removed before intrusive work commences or is completed, the PM, SC, or designee must notify the independent utility locate service or the designated local utility locating service to resurvey and remark the area.

12.3.4 Visual Assessment before and during Intrusive Activities

Perform a “360-degree” assessment. Walk the area and inspect for utility-related items such as valve caps, previous linear cuts, patchwork in pavement, hydrants, manholes, utility vaults, drains, and vent risers in and around the dig area.

The visual survey shall include all surface landmarks, including manholes, previous liner cuts, patchwork in pavement, pad-mounted transformers, utility poles with risers, storm sewer drains, utility vaults, and fire hydrants.

If any unanticipated items are found, conduct further research before initiating intrusive activities and implement any actions needed to avoid striking the utility or obstruction.

12.3.5 Subsurface Activities within 5 feet of an Underground Utility or if there is Uncertainty

When aggressive intrusive activities will be conducted within 5 feet (1.5 meters) of an underground utility or when there is uncertainty about utility locations, locations must be physically verified by non-aggressive means such as air or water knifing, hand digging, or human powered hand augering. Non-conductive tools must be used if electrical hazards may be present. If intrusive activities are within 5 feet (1.5 meters) and parallel to a marked existing utility, the utility location must be exposed and verified by non-aggressive methods every 100 feet (30.5 meters). Check to see if the utility can be isolated during intrusive work.

12.3.6 Intrusive Activities within 2 feet of an Underground Utility

Use non-aggressive methods (hand-digging, vacuum excavation, etc.) to perform intrusive activities within 2 feet of a high risk utility (i.e., a utility that cannot be de-energized or would cause significant impacts to repair/replace). Hazardous utilities shall be de-energized whenever possible.

12.3.7 Spotter

A spotter shall be used to monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon, presence of pea gravel or sand in soils, presence of concrete or other debris in soils, refusal of auger or excavating equipment). If any suspicious conditions are encountered stop work immediately and contact the PM or RHSM to evaluate the situation. The spotter must have a method to alert an operator to stop the intrusive activity (e.g., air horn, hand signals).

12.3.8 Utilities (Overhead)

12.3.8.1 Proximity to Power Lines

No work is to be conducted within 50 feet (15.2 meters) of overhead power lines without first contacting the utility company to determine the voltage of the system. No aspect of any piece of equipment is to be operated within 50 feet (15.2 meters) of overhead power lines without first making this determination.

Operations adjacent to overhead power lines are PROHIBITED unless one of the following conditions is satisfied:

- Power has been shut off, positive means (such as lockout) have been taken to prevent the lines from being energized, lines have been tested to confirm the outage, and the utility company has provided a signed certification of the outage.
- The minimum clearance from energized overhead lines is as shown in the table below, or the equipment will be repositioned and blocked to ensure that no part, including cables, can come within the minimum clearances shown in the following table.

Minimum Distances from Power Lines

Power Lines Nominal System kilovolt (kV)	Minimum Required Distance, feet (meters)
0–50	10 (3.0)
51–100	12 (3.7)
101–200	15 (4.6)
201–300	20 (6.1)
301–500	25 (7.6)
501–750	35 (10.7)
751–1,000	45 (13.7)

(These distances have been determined to eliminate the potential for arcing based on the line voltage.)

- The power line(s) has been isolated through the use of insulating blankets which have been properly placed by the utility. If insulating blankets are used, the utility will determine the minimum safe operating distance; get this determination in writing with the utility representative's signature.
- All inquiries regarding electric utilities must be made in writing and a written confirmation of the outage/isolation must be received by the PM prior to the start of work.

12.3.9 Manual Lifting

(Reference CH2M HILL SOP HSE-112, *Manual Lifting*)

Back injuries are the leading cause of disabling work injuries, and most back injuries are the result of improper lifting techniques or overexertion. Use the following to mitigate the hazards associated with lifting:

- When possible, the task should be modified to minimize manual lifting hazards.
- Lifting of loads weighing more than 40 pounds (18 kilograms) shall be evaluated by the SSC using the Lifting Evaluation Form contained in SOP HSE-112.
- Using mechanical lifting devices is the preferred means of lifting heavy objects such as forklifts; cranes, hoists, and rigging; hand trucks; and trolleys.
- Personnel shall seek assistance when performing manual lifting tasks that appear beyond their physical capabilities.

- In general, the following steps must be practiced when planning and performing manual lifts: Assess the situation before you lift; ensure good lifting and body positioning practices; ensure good carrying and setting down practices.
- All CH2M HILL workers must have training in proper manual lifting training either through the New Employee Orientation or through Manual Lifting module located on the Virtual Office.

12.3.10 Noise

(Reference CH2M HILL SOP HSE-108, *Hearing Conservation*)

CH2M HILL is required to control employee exposure to occupational noise levels of 85 decibels (dBA) and above by implementing a hearing conservation program that meets the requirements of the OSHA Occupational Noise Exposure standard, 29 CFR 1910.95. A noise assessment may be conducted by the RHSM or designee based on potential to emit noise above 85 dBA and also considering the frequency and duration of the task.

- Areas or equipment emitting noise at or above 90 dBA shall be evaluated to determine feasible engineering controls. When engineering controls are not feasible, administrative controls can be developed and appropriate hearing protection will be provided.
- Areas or equipment emitting noise levels at or above 85 dBA, hearing protection must be worn.
- Employees exposed to 84 dBA or a noise dose of 50 percent must participate in the Hearing Conservation program including initial and annual (as required) audiograms.
- The RHSM will evaluate appropriate controls measures and work practices for employees who have experienced a standard threshold shift (STS) in their hearing.
- Employees who are exposed at or above the action level of 85 dBA are required to complete the online Noise Training Module located on CH2M HILL's Virtual Office.
- Hearing protection will be maintained in a clean and reliable condition, inspected prior to use and after any occurrence to identify any deterioration or damage, and damaged or deteriorated hearing protection repaired or discarded.
- In work areas where actual or potential high noise levels are present at any time, hearing protection must be worn by employees working or walking through the area.
- Areas where tasks requiring hearing protection are taking place may become hearing protection required areas as long as that specific task is taking place.
- High noise areas requiring hearing protection should be posted or employees must be informed of the requirements in an equivalent manner.

12.3.11 Stairways and Ladders

(Reference CH2M HILL SOP HSE-214*, Stairways and Ladders*)

Below are the hazard controls and safe work practices to follow when using stairways and ladders. Ensure the requirements in the referenced SOP are followed.

- Stairway or ladder is generally required when a break in elevation of 19 inches (48.3 centimeters) or greater exists.
- Personnel should avoid using both hands to carry objects while on stairways; if unavoidable, use extra precautions.
- Personnel must not use pan and skeleton metal stairs until permanent or temporary treads and landings are provided the full width and depth of each step and landing.
- Ladders must be inspected by a competent person for visible defects prior to each day's use. Defective ladders must be tagged and removed from service.

- Ladders must be used only for the purpose for which they were designed and shall not be loaded beyond their rated capacity.
- Only one person at a time shall climb on or work from an individual ladder.
- User must face the ladder when climbing; keep belt buckle between side rails.
- Ladders shall not be moved, shifted, or extended while in use.
- User must use both hands to climb; use rope to raise and lower equipment and materials.
- Straight and extension ladders must be tied off to prevent displacement.
- Ladders that may be displaced by work activities or traffic must be secured or barricaded.
- Portable ladders must extend at least 3 feet (91.5 centimeters) above landing surface.
- Straight and extension ladders must be positioned at such an angle that the ladder base to the wall is one-fourth of the working length of the ladder.
- Stepladders are to be used in the fully opened and locked position.
- Users are not to stand on the top two steps of a stepladder; nor are users to sit on top or straddle a stepladder.
- Fixed ladders $\geq$ 24 feet (7.3 meters) in height must be provided with fall protection devices.

Fall protection should be considered when working from extension, straight, or fixed ladders greater than six feet (1.8 meters) from lower levels and both hands are needed to perform the work, or when reaching or working outside of the plane of ladder side rails.

12.3.12 Electrical Safety

(Reference CH2M HILL SOP HSE-206, *Electrical Safety*)

Below are the hazard controls and safe work practices to follow when using electrical tools, extension cords, and/or other electrical-powered equipment or when exposed to electrical hazards. Ensure the requirements of the referenced SOP are followed.

12.3.13 General Electrical Safety

- Only qualified personnel are permitted to work on unprotected energized electrical systems.
- Only authorized personnel are permitted to enter high-voltage areas.
- CH2M HILL employees who might from time to time work in an environment influenced by the presence of electrical energy must complete Awareness Level Electrical Safety Training located on the CH2M HILL Virtual Office.
- Do not tamper with electrical wiring and equipment unless qualified to do so. All electrical wiring and equipment must be considered energized until lockout/tagout procedures are implemented.
- Inspect electrical equipment, power tools, and extension cords for damage prior to use. Do not use defective electrical equipment, remove from service.
- CH2M HILL has selected GFCIs as the standard method for protecting employees from the hazards associated with electric shock.
  - GFCIs shall be used on all 120-volt, single phase 15 and 20-amphere receptacle outlets which are not part of the permanent wiring of the building or structure.
- An assured equipment grounding conductor program may be required under the following scenarios:
  - GFCIs cannot be used.

  - Client requires such a program to be implemented.
  - Business group decides to implement program in addition to GFCI protection.

- Extension cords must be equipped with third-wire grounding. Cords passing through work areas must be covered, elevated or protected from damage. Cords should not be routed through doorways unless protected from pinching. Cords should not be fastened with staples, hung from nails, or suspended with wire.
- Electrical power tools and equipment must be effectively grounded or double-insulated and Underwriters Laboratory (UL) approved.
- Operate and maintain electric power tools and equipment according to manufacturers' instructions.
- Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet (3 meters) from overhead power lines for voltages of 50 kV or less, and 10 feet (3 meters) plus ½ inch (1.27 centimeters) (for every 1 kV over 50 kV.
- Temporary lights shall not be suspended by their electric cord unless designed for suspension. Lights shall be protected from accidental contact or breakage.
- Protect all electrical equipment, tools, switches, and outlets from environmental elements.

12.3.14 Portable Generator Hazards

- Portable generators are useful when temporary or remote electric power is needed, but they also can be hazardous. The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire.
- NEVER use a generator indoors or in similar enclosed or partially-enclosed spaces. Generators can produce high levels of CO very quickly. When you use a portable generator, remember that you cannot smell or see CO. Even if you can’t smell exhaust fumes, you may still be exposed to CO.
- If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY. DO NOT DELAY. The CO from generators can rapidly lead to full incapacitation and death.
- If you experience serious symptoms, get medical attention immediately. Inform project staff that CO poisoning is suspected. If you experienced symptoms while indoors have someone call the fire department to determine when it is safe to re-enter the building.
- Follow the instructions that come with your generator. Locate the unit outdoors and away from doors, windows, and vents that could allow CO to come indoors.
- Keep the generator dry and do not use in rain or wet conditions. To protect from moisture, operate it on a dry surface under an open, canopy-like structure. Dry your hands if wet before touching the generator.
- Plug appliances directly into the generator. Or, use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin.
- Most generators come with GFCI. Test the GFCIs daily to determine whether they are working.
- If the generator is not equipped with GFCI protected circuits plug a portable GFCI into the generator and plug appliances, tools and lights into the portable GFCI.
- Never store fuel near the generator or near any sources of ignition.
- Before refueling the generator, turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite.

12.4 General Hazards

12.4.1 General Practices and Housekeeping

(Reference CH2M HILL SOP HSE-209, *General Practices*)

- Site work should be performed during daylight hours whenever possible. Work conducted during hours of darkness requires enough illumination intensity to read a newspaper without difficulty.
- Good housekeeping must be maintained at all times in all project work areas.
- Common paths of travel should be established and kept free from the accumulation of materials.
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions.
- Provide slip-resistant surfaces, ropes, and/or other devices to be used.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.

12.4.2 Hazard Communication

(Reference CH2M HILL SOP HSE-107, *Hazard Communication)*

The SSC is to perform the following:

- Complete an inventory of chemicals brought onsite by CH2M HILL using Attachment 2.
- Confirm that an inventory of chemicals brought onsite by CH2M HILL subcontractors is available.
- Request or confirm locations of MSDSs from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed.
- Before or as the chemicals arrive onsite, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly.
- Give employees the required chemical-specific Hazard Communication (HAZCOM) training using Attachment 3.
- Store all materials properly, giving consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

12.4.3 Shipping and Transportation of Chemical Products

(Reference CH2M HILL SOP HSE-403, *Hazardous Materials Handling)*

Chemicals brought to the site might be defined as hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (for example, via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the HSM or the Equipment Coordinator for additional information.

12.4.4 Heat Stress

(Reference CH2M HILL SOP HSE-211, *Heat and Cold Stress*)

Heat-related illnesses are caused by more than just temperature and humidity factors.

Physical fitness influences a person's ability to perform work under heat loads. At a given level of work, the more fit a person is, the less the physiological strain, the lower the heart rate, the lower the body temperature (indicates less retrained body heat—a rise in internal temperature precipitates heat injury), and the more efficient the sweating mechanism.

Acclimatization is a gradual physiological adaptation that improves an individual's ability to tolerate heat stress. Acclimatization requires physical activity under heat-stress conditions similar to those anticipated for the work. With a recent history of heat-stress exposures of at least two continuous hours per day for 5 of the last 7 days to 10 of the last 14 days, a worker can be considered acclimatized. Its loss begins when the activity under those heat-stress conditions is discontinued, and a noticeable loss occurs after 4 days and may be completely lost in three to four weeks. Because acclimatization is to the level of the heat-stress exposure, a person will not be fully acclimatized to a sudden higher level; such as during a heat wave.

Dehydration reduces body water volume. This reduces the body's sweating capacity and directly affects its ability to dissipate excess heat.

The ability of a body to dissipate heat depends on the ratio of its surface area to its mass (surface area/weight). **Heat dissipation** is a function of surface area, while heat production depends on body mass. Therefore, overweight individuals (those with a low ratio) are more susceptible to heat-related illnesses because they produce more heat per unit of surface area than if they were thinner. Monitor these persons carefully if heat stress is likely.

When wearing **impermeable clothing**, the weight of an individual is not as important in determining the ability to dissipate excess heat because the primary heat dissipation mechanism, evaporation of sweat, is ineffective.

SYMPTOMS AND TREATMENT OF HEAT STRESS

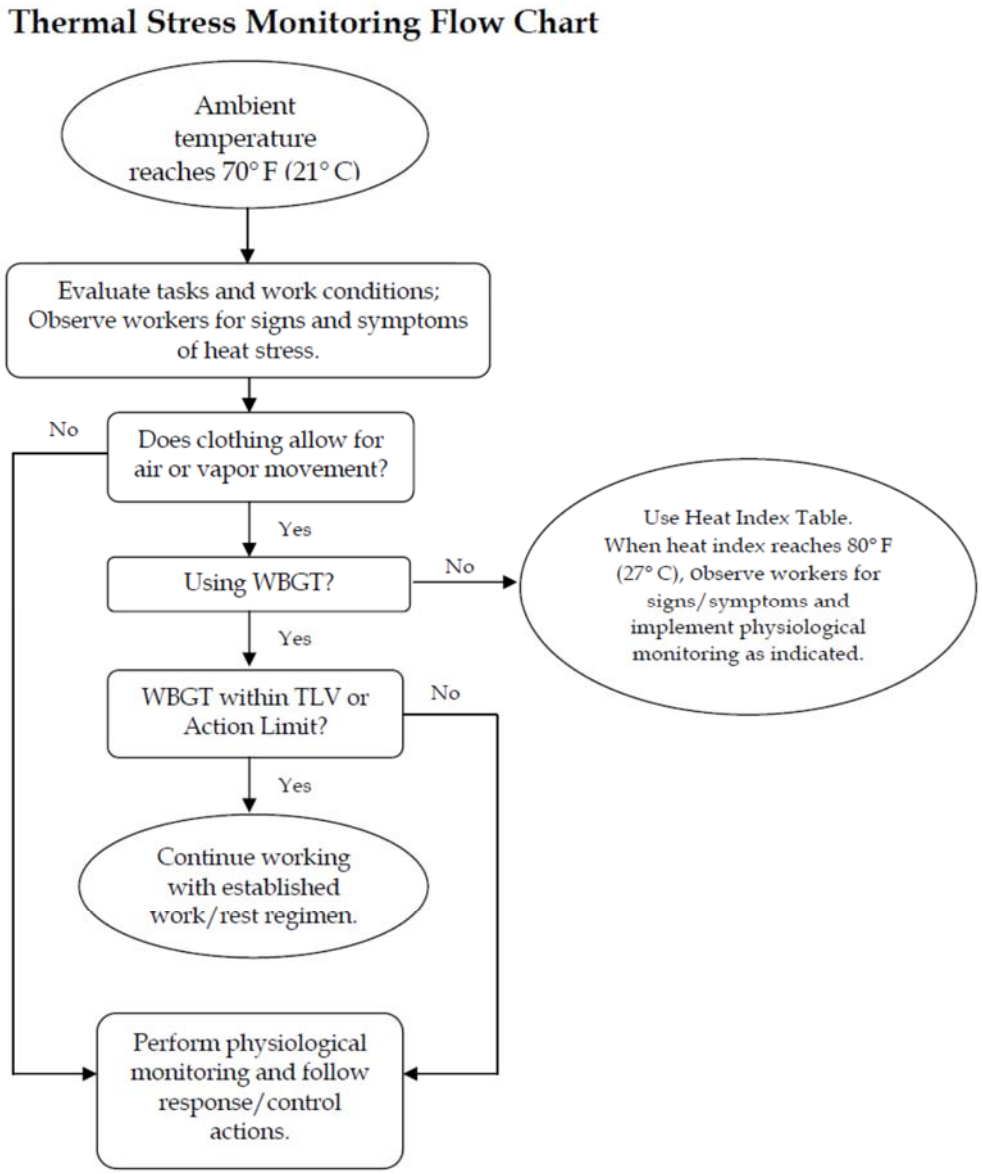
	Heat Syncope	Heat Rash	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool– but not cold– water. Call ambulance, and get medical attention immediately!

12.4.4.1 Precautions

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50 degrees Fahrenheit (^{o}F) (10 degrees Celsius [C]) to 60^{o}F (15.6^{o}C) should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons (7.5 liters) per day. Remind employees to drink water throughout their work shift.
- Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.

- Acclimate to site work conditions by slowly increasing workloads; for example, do not begin site work with extremely demanding activities. Closely monitor employees during their first 14 days of work in the field.
- Supervisors and SCs must continually observe employees throughout the work shift for signs and symptoms of heat stress or illness. Employees must monitor themselves for heat stress as well as observe their coworkers.
- Effective communication must be maintained with employees throughout the work shift either by voice, observation, or electronic device.
- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Avoid direct sun whenever possible, which can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.
- Provide adequate shade to protect personnel against radiant heat (sun, flames, hot metal).
- Use portable fans for convection cooling or in extreme heat conditions, an air-conditioned rest area when needed.
- In hot weather, rotate shifts of workers.
- Maintain good hygiene standards by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should consult medical personnel.
- Brief employees initially before the project work begins and routinely as part of the daily safety briefing, on the signs and symptoms, of heat-relatedness illnesses, precautions to measures and emergency procedures to follow as described in this plan.
- Observe one another for signs of heat stress. PREVENTION and communication are key.

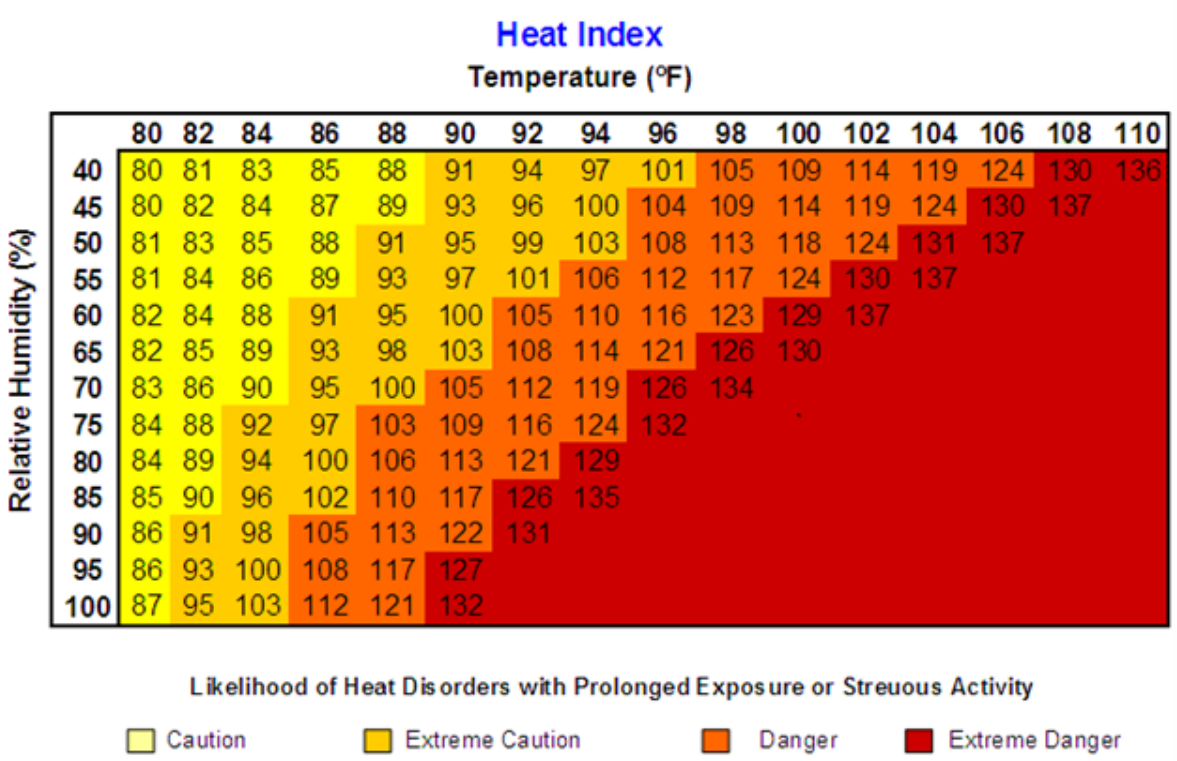
12.4.4.2 Thermal Stress Monitoring



12.4.4.3 Thermal Stress Monitoring—Permeable or Impermeable Clothing

When **permeable work clothes** are worn (street clothes or clothing ensembles over street clothes), regularly observe workers for signs and symptoms of heat stress and implement physiological monitoring as indicated below. This should start when the heat index reaches 80° F (27° C) [see Heat Index Table below], or sooner if workers exhibit symptoms of heat stress indicated in the table above. These heat index values were devised for shady, light wind conditions; exposure to full sunshine can increase the values by up to 15°F (8°C). Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

When wearing **impermeable clothing** (e.g., clothing doesn't allow for air or water vapor movement such as Tyvek), physiological monitoring as described below shall be conducted when the ambient temperature reaches 70° F (21° C) or sooner when climatic conditions may present greater risk of heat stress combined with wearing unique variations of impermeable clothing, or workers exhibit symptoms of heat stress.



Heat Index	Possible Heat Disorders	Minimum Frequency of Physiological Monitoring
80°F - 90°F (27°C - 32°C)	Fatigue possible with prolonged exposure and/or physical activity	Conduct initial monitoring as baseline and observe workers for signs of heat stress and implement physiological monitoring if warranted.
90°F - 105°F (32°C - 41°C)	Sunstroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity	Conduct initial monitoring as baseline, then at least every hour, or sooner, if signs of heat stress are observed.
105°F - 130°F (41°C - 54°C)	Sunstroke, heat cramps, or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity.	Conduct initial monitoring as baseline, then every 30 minutes or sooner if signs of heat stress are observed.
130°F or Higher (54°C or Higher)	Heat/Sunstroke highly likely with continued exposure.	Conduct initial monitoring as baseline, then every 15 minutes or sooner if signs of heat stress are observed.
Source: National Weather Service		

Physiological Monitoring and Associated Actions

For employees wearing permeable clothing, follow the minimum frequency of physiological monitoring listed in the Heat Index Table.

For employees wearing impermeable clothing, physiological monitoring should begin initially at a 15 minute interval, then if the employee's heart rate or body temperature is within acceptable limits, conduct the subsequent physiological monitoring at 30 minutes, and follow the established regimen protocol below.

The following physiological monitoring protocol below, using either radial pulse or aural temperature, will occur when the heat index is 80 degrees F or greater (or when personnel exhibit signs of heat stress), the following will be performed:

- The sustained heart rate during the work cycle should remain below 180 beats per minute (bpm) minus the individual's age (e.g. 180 – 35 year old person = 145 bpm). The sustained heart rate can be estimated by measuring the heart rate at the radial pulse for 30 seconds as quickly as possible prior to starting the rest period.
- The heart rate after one minute rest period should not exceed 120 beats per minute (bpm).
- If the heart rate is higher than 120 bpm after the FIRST minute into the rest period, the next work period should be shortened by 33 percent, while the length of the rest period stays the same.
- If the pulse rate still exceeds 120 bpm at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent.
- Continue this procedure until the rate is maintained below 120 bpm after the FIRST minute into the rest period.

Alternately, the body temperature can be measured, either oral or aural (ear), before the workers have something to drink.

- If the oral or aural temperature exceeds 99.6° F (37.6° F) at the beginning of the rest period, the following work cycle should be shortened by 33 percent.
- Continue this procedure until the oral or aural (ear) temperature is maintained below 99.6° F (37.6°C). While an accurate indication of heat stress, oral temperature is difficult to measure in the field, however, a digital aural (aural) thermometer is easy to obtain and inexpensive to purchase.
- Use the form attached to this HSP to track workers' measurements and actions taken.

12.4.4.4 Procedures for when Heat Illness Symptoms are Experienced

- **Always** contact the RHSM when any heat illness related symptom is experienced so that controls can be evaluated and modified, if needed.
- In the case of cramps, reduce activity, increase fluid intake, move to shade until recovered.
- In the case of all other heat-related symptoms (fainting, heat rash, heat exhaustion), and if the worker is a CH2M HILL worker, contact the occupational physician at 1-866-893-2514 and immediate supervisor.
- In the case of heat stroke symptoms, call 911, have a designee give location and directions to ambulance service if needed, follow precautions under the emergency medical treatment of this HSP.
- Follow the Incident Notification, Reporting, and Investigation section of this HSP.

12.4.5 Cold Stress

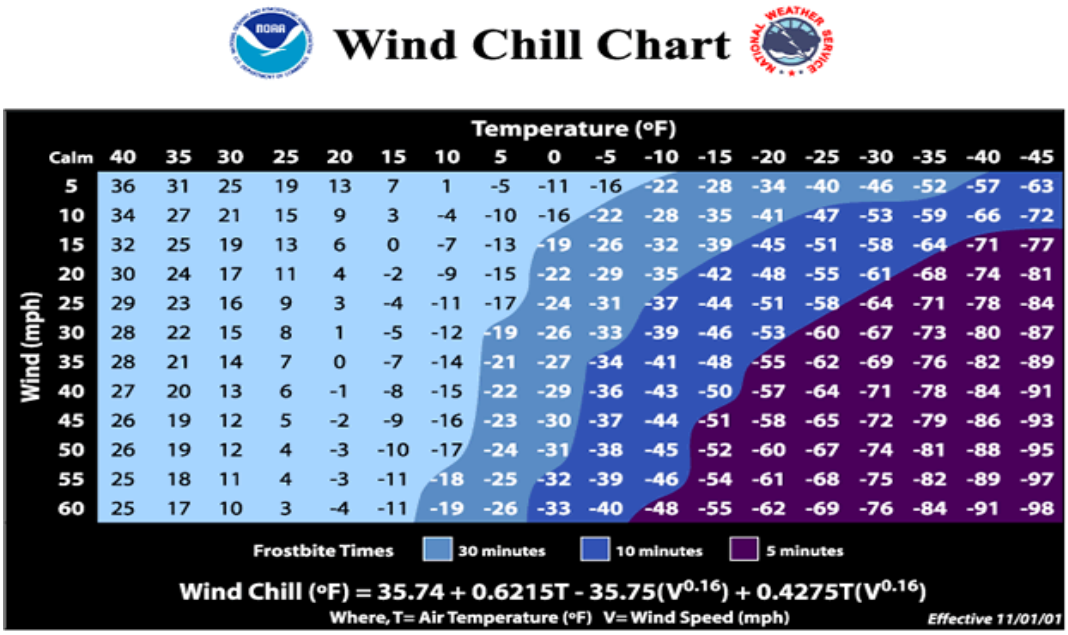
(Reference CH2M HILL SOP HSE-211, *Heat and Cold Stress*)

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in cool weather.
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- Wind-chill index is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it should only be used as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.
- NSC Guidelines for Work and Warm-Up Schedules can be used with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; workers should be monitored for symptoms of cold-related illnesses. If symptoms are not observed, the work duration can be increased.

- Persons who experience initial signs of immersion foot, frostbite, and/or hypothermia should consult the SSC to avoid progression of cold-related illness.
- Observe one another for initial signs of cold-related disorders.
- Obtain and review weather forecast—be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

TABLE 12-1
Symptoms and Treatment of Cold Stress

	Immersion (Trench) Foot	Frostbite	Hypothermia
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Rewarm area quickly in warm–but not hot–water. Have victim drink warm fluids, but not coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.



12.5 Biological Hazards and Controls

(Reference CH2M HILL SOP HSE-202, *Biological Hazards*)

12.5.1 Bees and Other Stinging Insects

Bee and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SSC and/or buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops.

12.5.2 Bloodborne Pathogens

(Reference CH2M HILL, SOP HSE-202, *Blood-borne Pathogens*)

Exposure to blood-borne pathogens may occur when rendering first-aid or CPR, or when coming into contact with landfill waste or waste streams containing potentially infectious material. Exposure controls and personal protective equipment are required as specified in CH2M HILL SOP HSE-202, *Blood-borne Pathogens*. Hepatitis B vaccination must be offered before the person participates in a task where exposure is a possibility.

12.5.3 Mosquito Bites

Due to the recent detection of the West Nile Virus in the southwestern United States it is recommended that **preventative measures** be taken to reduce the probability of being bitten by mosquitoes whenever possible. Mosquitoes are believed to be the primary source for exposure to the West Nile Virus as well as several other types of encephalitis. The following guidelines should be followed to reduce the risk of these concerns for working in areas where mosquitoes are prevalent.

- Stay indoors at dawn, dusk, and in the early evening.
- Wear long-sleeved shirts and long pants whenever you are outdoors.
- Repellents may irritate the eyes and mouth, so avoid applying repellent to the hands. Spray clothing with repellents containing permethrin or DEET since mosquitoes may bite through thin clothing.
- Apply insect repellent sparingly to exposed skin. An effective repellent will contain 35 percent DEET. DEET in high concentrations (greater than 35 percent) provides no additional protection.
- Whenever you use an insecticide or insect repellent, be sure to read and follow the manufacturer's DIRECTIONS FOR USE, as printed on the product.

Note: Vitamin B and "ultrasonic" devices are NOT effective in preventing mosquito bites.

12.6 Ticks

Every year employees are exposed to tick bites at work and at home putting them at risk of illness. Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch (6.4 mm) in size.

In some geographic areas exposure is not easily avoided. Wear tightly woven light-colored clothing with long sleeves and pant legs tucked into boots; spray only outside of clothing with permethrin or permanone and spray skin with only DEET; and check yourself frequently for ticks.

Where site conditions (vegetation above knee height, tick endemic area) or when tasks (having to sit or kneel in vegetation) diminish the effectiveness of the other controls mentioned above, bug-out suits (check with your local or regional warehouse) or Tyvek shall be used. Bug-out suits are more breathable than Tyvek.

Take precautions to avoid exposure by including pre-planning measures for biological hazards prior to starting field work. Avoid habitats where possible, reduce the abundance through habitat disruption or application of acracide. If these controls aren't feasible, contact your local or regional warehouse for preventative equipment such as repellants, protective clothing and tick removal kits. Use the buddy system and perform tick inspections prior to entering the field vehicle. If ticks were not planned to be encountered and are observed, do not continue field work until these controls can be implemented.

See Tick Fact Sheet attached to this HSP for further precautions and controls to implement when ticks are present. If bitten by a tick, follow the removal procedures found in the tick fact sheet, and call the occupational nurse at 1-866-893-2514.

Be aware of the symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme disease is a rash that might appear that looks like a bull's eye with a small welt in the center. RMSF is a rash of red spots under the skin

3 to 10 days after the tick bite. In both RMSF and Lyme disease, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, again contact the occupational nurse at 1-866-893-2514.

Be sure to complete an Incident Report (or use the Hours and Incident Tracking System [HITS] system on the Virtual Office) if you do come in contact with a tick.

12.6.1 Symptoms of Exposure to the West Nile Virus

Most infections are mild, and symptoms include fever, headache, and body aches, occasionally with skin rash and swollen lymph glands. More severe infection may be marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, paralysis, and, rarely, death.

The West Nile Virus incubation period is from 3 to 15 days.

If you have any questions or to report any suspicious symptoms, contact the project HSM.

13. Contaminants of Concern

Table 13-1 summarizes the potential contaminants of concern (COCs) and their occupational exposure limit and signs and symptoms of exposure. This table serves as general information regarding the specific compounds. These concentrations were used to determine engineering and administrative controls as well as PPE and site monitoring requirements. As a precaution, air monitoring will be conducted to prevent exposure from any potential inhalation pathway during the course of this investigation. See section 15.0 for specific details. Also, strict industrial hygiene practices will be enforced to prevent any other type of exposure pathway from occurring.

TABLE 13-1
Contaminants of Concern
(Refer to Project Files for additional contaminant information)

Contaminant	Location and Maximum[a] Concentration	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
VOCs					
Benzene Carbon tetrachloride Chloroform 1,2-dichloroethane cis-1,2 dichloroethene trans-1,2 dichloroethene Methylene chloride Naphthalene 1,1,1,2-tetrachlorethane (TeCA) 1,1,2,2-TeCA 1,1,2-trichloroethane Tetrachloroethene (PCE)		10 ppm	1,000	Skin, eye, and nose irritation; drowsiness; lack of coordination; CNS depression	9.07
Trichloroethene (TCE)		10 ppm	1,000 CA	Headache, vertigo, visual disturbance, eye and skin irritation, fatigue, giddiness, tremors, sleepiness, nausea, vomiting, dermatitis, cardiac arrhythmia, paresthesia, liver injury	9.45
Vinyl chloride					

Note:
[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), S (Surface Soil), SL (Sludge), SW (Surface Water).
[b] Appropriate value of Permissible Exposure Limit established by OSHA (PEL), recommended exposure limit (REL), or threshold limit value (TLV) listed.
[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.
[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

Potential Routes of Exposure

Dermal: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 4.

Inhalation: Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in Sections 4 and 5, respectively.

Other: Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

ppm: parts per million

14. Air Monitoring/Sampling

14.1 Site Monitoring

(Reference CH2M HILL SOP HSE-207, *Exposure Monitoring for Airborne Chemical Hazards*)

When performing site monitoring, record all the information, such as in a field logbook. Note date and time, describe monitoring location (for example, in breathing zone, at source, etc. and site location), and what the reading is. If any action levels are reached, note it in the field logbook and note the action taken.

Exposure records (air sampling) must be preserved for the duration of employment plus thirty years. Ensure that copies of the field log book are maintained in the project file.

Copies of all project exposure records (for example, copies of field logbook pages where air monitoring readings are recorded and associated calibration) shall be sent to the regional SPA for retention and maintained in the project files.

As the background information on COCs shows low to moderate levels, and the tasks involved in this SSHP do pose an exposure potential, the action limits are set for work to proceed in Level D only. If any action limit is exceeded, the work will be halted and the HSM shall be notified to assess and determine what further action is necessary.

14.2 Direct Reading Monitoring Specifications

Instrument	Tasks	Action Levels [a]	Action to be Taken when Action Level Reached	Frequency [b]	Calibration
Toxic Gas Monitor: MultiRAE Plus with 10.6 eV lamp (VOCs, O_2, LEL, CO, H_2S)	All sampling tasks Drilling	0-10 ppm >10 ppm	Level D Contact HSM, stop work.	Real time during all tasks	Daily
Noise-Level Monitor [d]	Drilling	<85 dB(A) 85-120 dB(A) 120 dB(A)	No action required Hearing protection required Stop; re-evaluate	Initially and periodically during task	Daily

[a] Action levels apply to sustained breathing-zone measurements above background.
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SSC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate.
[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry.
[d] Noise monitoring with either Type I or II meter set for A scale, slow response and audiometric testing also required.

14.3 Calibration Specifications

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
MultiRae or equivalent	H2S	CF = 25	25 ppm	0.5 lpm reg
	CO	CF = 50	50 ppm	T-tubing
	LEL	CF = 50	50 %	
	O2	CF = 20.9	20.9 %	
	100 ppm isobutylene	CF = 100	100 ppm	

Calibrate air monitoring equipment daily (or prior to use) in accordance with the instrument's instructions. Document the calibration in the field logbook (or equivalent) and include the following information:

- Instrument name
- Serial number
- Owner of instrument (for example, CH2M HILL, HAZCO)
- Calibration gas (including type and lot number)
- Type of regulator (for example, 1.5 liters per minute [lpm])
- Type of tubing (for example, direct or T-tubing)
- Ambient weather condition (for example, temperature and wind direction)
- Calibration/instrument readings
- Operator's name and signature
- Date and time

15. Incident Notification and Reporting

(Reference CH2M HILL SOP HSE-111, Incident Reporting and Investigation)

- In case of an emergency immediately contact the Police, Fire, and Medical Emergency dispatch by dialing 911**.**
  - Severe bleeding
  - Loss of consciousness
  - Chest pain
  - Broken bones

15.1 General Information

This section applies to the following:

- All injuries involving employees, third parties, or members of the public
- Damage to property or equipment
- Interruptions to work or public service (e.g., hitting a utility)
- Incidents which attract negative media coverage
- Near misses
- Spills, leaks, or regulatory violations
- Motor vehicle accidents

Documentation, including incident reports, investigation, analysis and corrective measure taken, shall be kept by the SSC and maintained onsite for the duration of the project.

15.2 Section Definitions

Incident: an undesired event which results or could have resulted in loss through injury, damage to assets or environmental harm. This includes all of the definitions below.

Accident: an incident involving actual loss through injury, damage to assets, or environmental harm.

Near Miss: an unsafe act or incident which, in other circumstances, could have resulted in loss through injury, damage to assets, or environmental harm.

Serious Incident:

- All fatalities including contractors, subcontractors, third parties, or members of the public
- Kidnap/missing person
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage.
- Acts or threats of terrorism
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community, or the environment

15.3 Reporting Requirements

All employees and subcontractors' employees shall immediately report any incident (including "near misses," as defined in the section above) in which they are involved or witness to their supervisor.

The CH2M HILL or Subcontractor supervisor, upon receiving an incident report, shall inform his immediate superior and the CH2M HILL SSC.

The SSC shall immediately report the following information to the HSM and PM by phone and e-mail:

- Project Name/Site Manager
- Date and time of incident
- Description of incident
- Extent of known injuries/damage
- Level of medical attention
- Preliminary root cause/corrective actions

The SSC shall complete an entry into the Hours and Incident Tracking System (HITS) database system located on CH2M HILL's Virtual Office (or if Virtual Office not available, use the hard copy Incident Report Form and Root Cause Analysis Form and forward it to the HSM) within 24 hours and finalize those forms within 3 calendar days.

The CH2M HILL team shall comply with all applicable statutory incident reporting requirements such as those to OSHA and the police.

15.4 HITS System and Incident Report Form

It is the policy of CH2M HILL to maintain a HITS entry and/or IRF for all work-related injuries and illnesses sustained by its employees in accordance with recordkeeping and insurance requirements. A HITS entry and/or IRF will also be maintained for other incidents (property damage, fire or explosion, spill, release, potential violation, and near misses) as part of our loss prevention and risk reduction initiative.

15.5 Injury Management/Return-to-Work (for CH2M HILL Staff Only)

(Reference CH2M HILL, SOP HSSE-124, Injury Management/Return-to-Work)

15.5.1 Background

The Injury Management Program has been established to provide orderly, effective and timely medical treatment and return-to-work transition for an employee who sustains a work-related injury or illness. It also provides guidance and assistance with obtaining appropriate treatment to aid recovery, keep supervisors informed of employee status, and to quickly report and investigate work-related injury/illnesses to prevent recurrence.

To implement the Injury Management/Return-to-Work Program successfully, supervisors and/or SC should:

- Ensure employees are informed of the Injury Management/Return-to-Work Program.
- Become familiar with the Notification Process (detailed below).
- Post the Injury Management/Return-to-Work Notification Poster.

15.5.2 The Injury Management/Return-to-Work Notification Process

- Employee informs their Supervisor.
- Employee calls the Injury Management Program toll free number 1-866-893-2514 immediately and speaks with the Occupational Injury Nurse. This number is operable 24 hours per day, 7 days a week.
- Supervisor ensures employee immediately calls the Injury Management Program number and HSM. Supervisor makes the call with the injured worker or for the injured worker if needed.
- Nurse assists employee with obtaining appropriate medical treatment, as necessary schedules clinic visit for employee (calls ahead, and assists with any necessary follow up treatment) with the supervisor or SSC accompany the employee if a clinic visit is necessary to ensure that employees receive appropriate and timely care.

- Supervisor/SSC completes the HITS entry or Incident Report Form immediately (within 24 hours) and forwards it to the PM and HSM.
- Nurse notifies appropriate CH2M HILL staff by e-mail (supervisor, Health & Safety, Human Resources, Workers' Compensation).
- Nurse communicates and coordinates with and for employee on treatment through recovery.
- Supervisor ensures suitable duties are identified and available for injured/ill workers who are determined to be medically fit to return to work on transitional duty (temporary and progressive).
- Supervisor ensures medical limitations prescribed (if any) by physician are followed until the worker is released to full duty.

15.6 Serious Incident Reporting Requirements

(Reference CH2M HILL SOP HSE-111, Incident Reporting, Notification and Investigation)

The Serious Incident Reporting Requirements ensures timely notification and allows for positive control over flow of information so that the incident is handled effectively, efficiently, and in conjunction with appropriate corporate entities. This standard notification process integrates HSSE and Firm Wide Security Operations (FWSO) requirements for the consistent reporting of and managing of serious events throughout our operations.

15.6.1 Serious Incident Determination

The following are general criteria for determining whether an incident on CH2M HILL owned or managed facilities or program sites is considered serious and must be immediately reported up to Group President level through the reporting/notification process:

- Work related death, or life threatening injury or illness of a CH2M HILL employee, subcontractor, or member of the public
- Kidnap/missing person
- Acts or threats of terrorism
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment

15.6.2 Serious Incident Reporting

If an incident meets the "Serious Incident" criteria, the PM is to immediately contact the Crisis Manager at 720-286-4911, then follow the standard incident reporting procedure.

For all serious incidents this standard reporting process is implemented immediately so as to ultimately achieve notification to the Business Group President within 2 hours of incident onset or discovery, and notification to appropriate corporate Crisis Management Support Team.

15.7 Incident Root Cause Analysis

The accident analysis is essential if all causes of the incident are to be identified for the correct remedial actions to be taken to prevent the same and similar type of incident from recurring. The investigation team will consist of the SSC (with support from HSM), appropriate subcontractor personnel as necessary, the PM, and the responsible supervisor. More participants may be involved as needed to complete the investigation.

The Root Cause Analysis Form must be completed for all Loss Incidents and Near Loss Incidents. This form must be submitted to the investigation team for review.

For minor losses or near losses, the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, determine the root cause, and develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must use the Root Cause Analysis Flow Chart to assist in identifying the root cause(s) of a loss. Any loss may have one or more root causes and contributing factors. The root cause is the primary or immediate cause of the incident, while a contributing factor is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the person involved in the loss, his or her peers, or the supervisor should be referred to as “personal factors.” Causes that pertain to the system within which the loss or injury occurred should be referred to as “job factors.”

15.7.1 Personal Factors

- Lack of skill or knowledge
- Correct way takes more time and/or requires more effort
- Short-cutting standard procedures is positively reinforced or tolerated
- Person thinks there is no personal benefit to always doing the job according to standards

15.7.2 Job Factors

- Lack of or inadequate operational procedures or work standards
- Inadequate communication of expectations regarding procedures or standards
- Inadequate tools or equipment

The root cause(s) could be any one or a combination of these seven possibilities or some other uncontrollable factor. In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates all seven other factors.

15.7.3 Corrective Actions

Include all corrective actions taken or those that should be taken to prevent recurrence of the incident. Include the specific actions to be taken, the employer and personnel responsible for implementing the actions, and a timeframe for completion. Be sure the corrective actions address the causes.

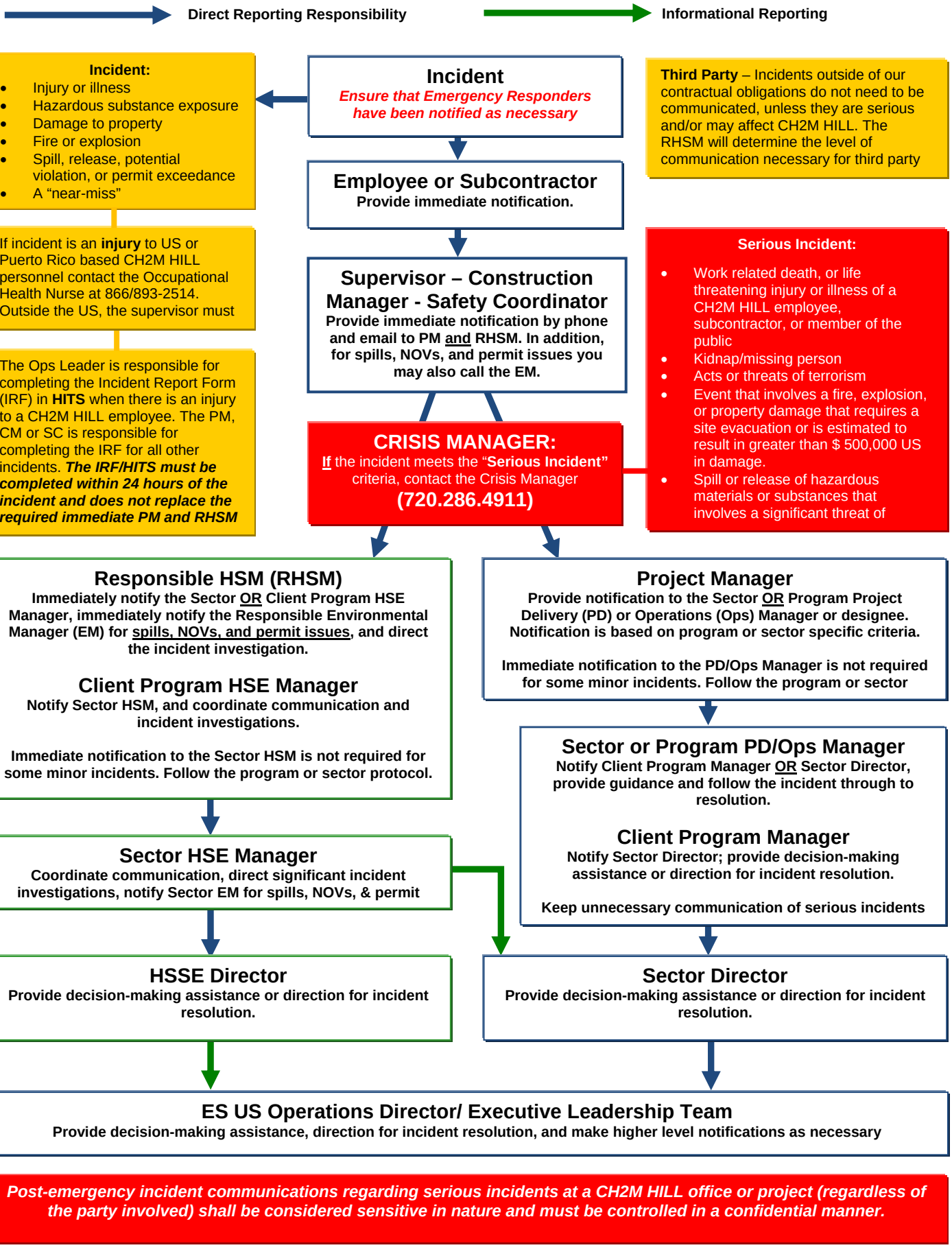
Once the investigation report has been completed, the PM shall hold a review meeting to discuss the incident and provide recommendations. The responsible supervisors shall be assigned to carry out the recommendations, and shall inform the SSC upon successful implementation of all recommended actions.

- The HSM will inform the Responsible Environmental Manager (REM) of any environmental incidents.
- Evaluation and follow-up of the IRF will be completed by the type of incident by the HSM, REM, or FWSO. The Business Group (BG) HSE Lead will review all BG incidents and modify as required.

Incident Investigations must be initiated and completed as soon as possible but no later than 72 hours after the incident.

Note: See the following Incident Notification flowchart.

ESBG US Operations
Incident Reporting Flow Diagram



16. Behavioral Based Loss Prevention

Research shows that 90 percent of incidents are related to unsafe acts and 10 percent are related to unsafe conditions. This means 90 percent of incidents are self-inflicted.

A Behavior Based Loss Prevention System (BBLPS) is a system to prevent or reduce losses using behavior-based tools and proven management techniques to focus on behaviors or acts that could lead to losses.

The four basic Loss Prevention tools that will be used during this project to implement the BBLPS include:

- AHA
- PTSP
- Loss Prevention Observations (LPOs)
- Loss and Near Loss Investigations (NLI)

The Site Supervisor serves as the SSC and is responsible for implementing the BBLPS on this site. When a separate individual is assigned as the SSC, the SSC is delegated authority from the Site Supervisor to implement the BBLPS on the project site, but the Site Supervisor remains accountable for its implementation. The Site Supervisor/SSC shall only oversee the subcontractor's implementation of their AHAs and PTSPs processes on the project.

16.1 Activity Hazard Analysis

An AHA defines the activity being performed, the hazards posed and control measures required to perform the work safely. Workers are briefed on the AHA before doing the work and their input is solicited prior, during and after the performance of work to further identify the hazards posed and control measures required.

The Project AHAs are provided in Attachment 8. The AHAs identify the work tasks required to perform each activity, along with potential Health & Safety hazards and recommended control measures for each work task. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

AHAs are prepared for all field activities performed by CH2M HILL and subcontractor during the course of the project by the Site Supervisor/SSC. The Project-specific and General Hazards of the SSHP, the Task Hazard Analysis Table, and applicable CH2M HILL SOPs are used as a basis for preparing CH2M HILL's AHAs.

CH2M HILL subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by CH2M HILL. Each subcontractor shall submit AHAs for their field activities, as defined in their work plan/scope of work, along with their project-specific SSHP. Additions or changes in CH2M HILL or subcontractor field activities, equipment, tools or material to perform work or additional/different hazard encountered that require additional/different hazard control measures requires either a new AHA to be prepared or an existing AHA to be revised.

16.2 Pre-task Safety Plans

Daily safety meetings shall be held with all project personnel in attendance to review the hazards posed and required H&S procedures/AHAs that apply for each day's project activities. The PTSPs serve the same purpose as these general assembly safety meetings, but the PTSPs are held between the crew supervisor and their work crews to focus on those hazards posed to individual work crews. At the start of each day's activities, the crew supervisor completes the PTSP, provided in Attachment 9, with input from the work crew, during their daily safety meeting. The day's tasks, personnel, tools and equipment that will be used to perform these tasks are listed, along with the hazards posed and required H&S procedures, as identified in the AHA. The use of PTSPs better promotes worker participation in the hazard recognition and control process, while reinforcing the task-specific hazard and

required H&S procedures with the crew each day. The use of PTSPs is a common safety practice in the construction industry.

16.3 Loss Prevention Observations/Safe Work Observations

LPOs shall be conducted by Site Supervisor/SSC for specific work tasks or operations comparing the actual work process against established safe work procedures identified in this SSHP (Drilling Self-Assessment Checklist, Hand and Power Tool Self-Assessment Checklist, and other relevant self-assessment checklists) and AHAs. LPOs are a tool to be used by supervisors to provide positive reinforcement for work practices performed correctly, while also identifying and eliminating deviations from safe work procedures that could result in a loss. Site Supervisor/SSC shall perform at least one LPO each week for tasks/operations addressed in this SSHP and AHAs. The Site Supervisor/SSC shall complete the LPO form in Attachment 10 for the task/operation being observed.

16.4 Loss/Near Loss Investigations

Loss/Near Loss Investigations shall be performed for the all CH2M HILL and subcontractor incidents involving:

- Person injuries/illnesses and near miss injuries
- Equipment/property damage
- Spills, leaks, regulatory violations
- Motor vehicle accidents

The causes of loss and near loss incidents are similar, so by identifying and correcting the causes of near loss causes, future loss incidents may be prevented. The following is the Loss/Near Loss Investigation Process:

- Gather all relevant facts, focusing on fact-finding, not fault-finding, while answering the who, what, when, where, and how questions.
- Draw conclusions, pitting facts together into a probable scenario.
- Determine incident root cause(s), which are basic causes on why an unsafe act/condition existed.
- Develop and implement solutions, matching all identified root causes with solutions.
- Communicate incident as a Lesson Learned to all project personnel.
- File follow-up on implemented corrective active action to confirm solution is appropriate.

Site Supervisors/SSC shall perform an incident investigation, as soon as practical after incident occurrence during the day of the incident, for all Loss and Near Loss Incidents that occur on the project. Loss and Near Loss incident investigations shall be performed using the following incident investigation forms provided in Attachment 11:

- IRF
- Root Cause Analysis Form

All Loss and Near Loss incident involving personal injury, property damage or near loss incidents that could have resulted in serious consequences shall be investigated by completing the incident investigation forms and submitting them to the PM and HSM within 24 hours of incident occurrence. A preliminary Incident Investigation and Root Cause Analysis shall be submitted to the PM and HSM within 24 hours of incident occurs. The final Incident Investigation and Root Cause Analysis shall be submitted after completing a comprehensive investigation of the incident.

Attachments

Attachment 1:	Employee Signoff Sheet
Attachment 2:	Project-specific Chemical Product Hazard Communication Form
Attachment 3:	Chemical-specific Training Form
Attachment 4:	Emergency Contacts List and Emergency Response Plan
Attachment 5:	Project Activity Self-assessment Checklists
Attachment 6:	Project-specific Material Safety Data Sheets
Attachment 7:	Initial Medical Treatment Form
Attachment 8:	Project Activity Hazard Analyses
Attachment 9:	Pre-task Safety Plan
Attachment 10:	Safe Work Observation Form
Attachment 11:	Loss/Near-loss Investigations

Employee Signoff Sheet

CH2MHILL

EMPLOYEE SIGNOFF FORM

Health and Safety Plan

- The CH2M HILL project employees and subcontractors listed below have been provided with a copy of this SSHP, have read and understood it, and agree to abide by its provisions.

Project Name: **Project Number:**

EMPLOYEE NAME (Please print)	**EMPLOYEE SIGNATURE**	**COMPANY**	**DATE**

Project-specific Chemical Product Hazard Communication Form

CH2MHILL

Project-Specific Chemical Product Hazard Communication Form

This form must be completed prior to performing activities that expose personnel to hazardous chemicals products. Upon completion of this form, the SSC shall verify that training is provided on the hazards associated with these chemicals and the control measures to be used to prevent exposure to CH2M HILL and subcontractor personnel. Labeling and MSDS systems will also be explained.

Project Name: **Project Number:**

MSDSs will be maintained at the following location(s):

Hazardous Chemical Products Inventory

Chemical	*Quantity*	Chemical	*Quantity*	Chemical	

Chemical-specific Training Form

CH2MHILL

CHEMICAL-SPECIFIC TRAINING FORM

Location:	Project #:
HCC:	Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product MSDS to provide the following information concerning each of the products listed above.

☐ Physical and health hazards

☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)

☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of MSDSs, chemical inventories, and CH2M HILL's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

Emergency Contacts List and Emergency Response Plan

Emergency Contacts

24-hour CH2M HILL Serious Incident Reporting Contact/Pager – 720-286-4911

If injured on the job, notify your supervisor and then call 1-866-893-2514 to contact CH2M HILL's Occupational Nurse

Medical Emergency – 911 Facility Medical Response #: Local Ambulance #:	CH2M HILL- Medical Consultant WorkCare Dr. Peter Greaney M.D. 300 S. Harbor Blvd, Suite 600 Anaheim , CA 92805 800-455-6155 714-978-7488
Fire/Spill Emergency -- 911 Facility Fire Response #: Local Fire Dept #:	CH2M HILL Director – HSSE Andy Strickland/DEN (720) 480-0685 (cell) or (720) 286-2393 (office)
Security & Police – 911 Facility Security #: Local Police #:	CH2M HILL Responsible Health and Safety Manager (RHSM) Name: Mark Orman Phone: 414-712-4138
Utilities Emergency Water: 911 Gas: 911 Electric: 911	**CH2M HILL Environmental Compliance Coordinator** Name: Jenny Lindquist Phone: +1 (530) 209-2234
Site Safety Coordinator (SSC) Name: Glynn Roberts Phone: +1 (314) 324-4161	CH2M HILL Human Resources Department Name: One HR, (online) Phone:
Project Manager Name: Chris English Phone: 314-335-3012	CH2M HILL Worker's Compensation: Contact Business Group HR dept. to have form completed or contact Jennifer Rindahl after hours: (720)891-5382
CH2M HILL Safety Coordinator Name: Tony Swierczek Phone: 314-335-3043	Media Inquiries Corporate Strategic Communications Name: John Corsi Phone: (720) 286-2087
	Automobile Accidents Rental: Jennifer Rindahl/DEN: 720-286-2449 CH2M HILL-owned vehicle: Linda George/DEN: 720-286-2057

Federal Express Dangerous Goods Shipping
Phone: 800/238-5355

CH2M HILL Emergency Number for Shipping Dangerous Goods
Phone: 800/255-3924

Contact the Project Manager. Generally, the Project Manager will contact relevant government agencies.

Facility Alarms: Sound Field Vehicle Horn (3x) **Evacuation Assembly Area(s):** Field Vehicle

Facility/Site Evacuation Route(s): See Site Map

Hospital Name/Address:
Barnes-Jewish Hospital (South)
4921 Parkview Pl
Saint Louis, MO 63110
(314) 747-3000 Website More Info

Emergency Response Plan

Emergency Preparedness Training

The emergency response plan will be reviewed during the initial arrival to the jobsite and occasionally during site safety briefings. The briefings should include:

- Emergency procedures for fires, explosions, chemical and vapor releases, personnel injuries, and suspected overexposure as they apply to the site
- Location of onsite emergency equipment and supplies of clean water
- Local emergency contacts, evacuation routes, and assembly points
- Site communication and location of phone and radio nearest
- Names of onsite personnel trained in first-aid and CPR

Emergency Equipment and Supplies

The SSC will verify that these supplies are available, as needed, and in proper working order, and mark the locations of emergency equipment on the site map when a map is provided.

Emergency Equipment and Supplies

Emergency Equipment and Supplies	Location
2 fire extinguishers (A, B, and C classes)	Field vehicle
First-aid kit	Field vehicle
Eye wash	Field vehicle
Potable water	Field vehicle
Blood-borne pathogen kit	Field vehicle
Additional equipment (specify):	Cell phone: SSC

Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Shut down operations and evacuate the immediate area
- Notify the SSC and PM by the fastest means available.
- Account for personnel at the designated assembly area(s)
- Assess the need for site evacuation, and evacuate the site as warranted
- Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled

Emergency Medical Treatment

The procedures listed below may also be applied to nonemergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to CH2M HILL HSM/Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the CH2M HILL medical consultant (see Emergency Contacts List in Attachment 4). During non-emergencies, follow these procedures as appropriate.

- Notify appropriate emergency response authorities. **Contact the police, fire, and medical emergency dispatch by dialing** 911.
- The SSC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first-aid and CPR (if needed) where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible; lifesaving and first-aid or medical treatment take priority.
- Make certain that the injured person is accompanied to the emergency room.
- When contacting the medical consultant, state that the situation is a CH2M HILL matter, and give your name and telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.

Evacuation Procedures

- Evacuation routes and assembly areas will be designated by the SSC before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if safe) to inform local responders of the nature and location of the incident.
- Each supervisor will account for their personnel at the assembly area, and report to the PM or CSP/HSM that either all personnel are accounted for, or the number of personnel who are unaccounted.
- The SSC will write up the incident as soon as possible after it occurs and submit a report to the PM and/or CSP/HSM.

Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

Firefighting Plan

(References: Section 01.E.01 & 06.A.02, EM 385-1-1 and CH2M HILL SOP HSE-208, *Fire Prevention*)

The decision on whether or not to try to extinguish a fire using available site personnel and equipment will be made by the SSC, and is based on whether the fire is small or large, and involves explosives or flammable liquids/gases.

Location of Fire Extinguishers

Fire extinguishers will be located around the project sites as required. These will be located in the following places at a minimum:

- In each vehicle
- Near areas where flammable materials are stored or in use
- Locations where HOT Work permits are in place

All fire extinguishers will be kept clearly visible, marked, and placed where they are easily accessible.

Project Activity Self-assessment Checklists

CH2MHILL

HS&E Self-Assessment Checklist - DRILLING

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's written safety plan.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to drilling hazards, 2) CH2M HILL staff are providing support function related to drilling activities, and/or 3) CH2M HILL oversight of a drilling subcontractor is required.

Safety Coordinator may consult with drilling subcontractors when completing this checklist, but shall not direct the means and methods of drilling operations nor direct the details of corrective actions. Drilling subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately, or all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to drilling hazards (complete Section 1).
☐ Evaluate CH2M HILL support functions related to drilling activities (complete Section 2)
☐ Evaluate a CH2M HILL subcontractor's compliance with drilling safety requirements (complete entire checklist).
Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the drilling subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in SOP HSE-204.

SECTION 1 - SAFE WORK PRACTICES (4.1)

	Yes	No	N/A	N/O
1. Personnel cleared during rig startup	☐	☐	☐	☐
2. Personnel clear of rotating parts	☐	☐	☐	☐
3. Personnel not positioned under hoisted loads	☐	☐	☐	☐
4. Loose clothing and jewelry removed	☐	☐	☐	☐
5. Smoking is prohibited around drilling operation	☐	☐	☐	☐
6. Personnel wearing appropriate personal protective equipment (PPE), per written plan	☐	☐	☐	☐
7. Personnel instructed not to approach equipment that has become electrically energized	☐	☐	☐	☐

SECTION 2 - SUPPORT FUNCTIONS (4.2)

FORMS/PERMITS (4.2.1)

8. Driller license/certification obtained	☐	☐	☐	☐
9. Well development/abandonment notifications and logs submitted and in project files	☐	☐	☐	☐
10. Water withdrawal permit obtained, where required	☐	☐	☐	☐
11. Dig permit obtained, where required	☐	☐	☐	☐

UTILITY LOCATING (4.2.2)

12. Location of underground utilities and structures identified	☐	☐	☐	☐

SECTION 2 (Continued)

	Yes	No	N/A	N/O
WASTE MANAGEMENT (4.2.3)				
13. Drill cuttings and purge water managed and disposed properly	☐	☐	☐	☐
DRILLING AT HAZARDOUS WASTE SITES (4.2.4)				
14. Waste disposed of according to project's written safety plan	☐	☐	☐	☐
15. Appropriate decontamination procedures being followed, per project's written safety plan	☐	☐	☐	☐
DRILLING AT MUNITIONS RESPONSE (4.2.5)				
16. MEC plan prepared and approved	☐	☐	☐	☐
17. MEC avoidance provided, routes and boundaries cleared and marked	☐	☐	☐	☐
18. Initial pilot hole established by UXO technician with hand auger	☐	☐	☐	☐
19. Personnel remain inside cleared areas	☐	☐	☐	☐
SECTION 3 - DRILLING SAFETY REQUIREMENTS (4.3)				
GENERAL (4.3.1)				
20. Only authorized personnel operating drill rigs	☐	☐	☐	☐
21. Daily safety briefing/meeting conducted with crew	☐	☐	☐	☐
22. Daily inspection of drill rig and equipment conducted before use	☐	☐	☐	☐
DRILL RIG PLACEMENT (4.3.2)				
23. Location of underground utilities and structures identified	☐	☐	☐	☐
24. Safe clearance distance maintained from overhead power lines	☐	☐	☐	☐
25. Drilling pad established, when necessary	☐	☐	☐	☐
26. Drill rig leveled and stabilized	☐	☐	☐	☐
27. Additional precautions taken when drilling in confined areas	☐	☐	☐	☐
DRILL RIG TRAVEL (4.3.3)				
28. Rig shut down and mast lowered and secured prior to rig movement	☐	☐	☐	☐
29. Tools and equipment secured prior to rig movement	☐	☐	☐	☐
30. Only personnel seated in cab are riding on rig during movement	☐	☐	☐	☐
31. Safe clearance distance maintained while traveling under overhead power lines	☐	☐	☐	☐
32. Backup alarm or spotter used when backing rig	☐	☐	☐	☐
DRILL RIG OPERATION (4.3.4)				
33. Kill switch clearly identified and operational	☐	☐	☐	☐
34. All machine guards are in place	☐	☐	☐	☐
35. Rig ropes not wrapped around body parts	☐	☐	☐	☐
36. Pressurized lines and hoses secured from whipping hazards	☐	☐	☐	☐
37. Drill operation stopped during inclement weather	☐	☐	☐	☐
38. Air monitoring conducted per written safety plan for hazardous atmospheres	☐	☐	☐	☐
39. Rig placed in neutral when operator not at controls	☐	☐	☐	☐
DRILL RIG SITE CLOSURE (4.3.5)				
40. Ground openings/holes filled or barricaded	☐	☐	☐	☐
41. Equipment and tools properly stored	☐	☐	☐	☐
42. All vehicles locked and keys removed	☐	☐	☐	☐
DRILL RIG MAINTENANCE (4.3.6)				
28. Defective components repaired immediately	☐	☐	☐	☐
29. Lockout/tagout procedures used prior to maintenance	☐	☐	☐	☐
30. Cathead in clean, sound condition	☐	☐	☐	☐
31. Drill rig ropes in clean, sound condition	☐	☐	☐	☐
32. Fall protection used for fall exposures of 6 feet (U.S.) 1.5 meters (Australia) or greater	☐	☐	☐	☐
33. Rig in neutral and augers stopped rotating before cleaning	☐	☐	☐	☐
34. Good housekeeping maintained on and around rig	☐	☐	☐	☐

SECTION 4

Complete this section for all items checked "No" in previous sections. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: _____ Project Manager: _____

CH2MHILL

HS&E Self-Assessment Checklist—HAND AND POWER TOOLS

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: (1) CH2M HILL employees are exposed to hand and power tool hazards and/or (2) CH2M HILL provides oversight of subcontractor personnel who are exposed to hand and power tool hazards.

SC may consult with subcontractors when completing this checklist, but shall not direct the means and methods of hand and power tool use nor direct the details of corrective actions. Subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Completed checklists shall be sent to the HS&E Staff for review.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposure to hand and power tool hazards.
☐ Evaluate a CH2M HILL subcontractor's compliance with hand and power tool requirements.
Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-210.

SECTION 1

	Yes	No	N/A	N/O
SAFE WORK PRACTICES (3.1)				
1. All tools operated according to manufacturer's instructions and design limitations.	☐	☐	☐	☐
2. All hand and power tools maintained in a safe condition and inspected and tested before use.	☐	☐	☐	☐
3. Defective tools are tagged and removed from service until repaired.	☐	☐	☐	☐
4. PPE is selected and used according to tool-specific hazards anticipated.	☐	☐	☐	☐
5. Power tools are not carried or lowered by their cord or hose.	☐	☐	☐	☐
6. Tools are disconnected from energy sources when not in use, servicing, cleaning, etc.	☐	☐	☐	☐
7. Safety guards remain installed or are promptly replaced after repair.	☐	☐	☐	☐
8. Tools are stored properly.	☐	☐	☐	☐
9. Cordless tools and recharging units both conform to electrical standards and specifications.	☐	☐	☐	☐
10. Tools used in explosive environments are rated for such use.	☐	☐	☐	☐
11. Knife or blade hand tools are used with the proper precautions.	☐	☐	☐	☐
12. Consider controls to avoid muscular skeletal, repetitive motion, and cumulative trauma stressors.	☐	☐	☐	☐

SECTION 2	Yes	No	N/A	N/O
GENERAL (3.2.1)				
13. PPE is selected and used according to tool-specific hazards anticipated.	☐	☐	☐	☐
14. Tools are tested daily to assure safety devices are operating properly.	☐	☐	☐	☐
15. Damaged tools are removed from service until repaired.	☐	☐	☐	☐
16. Power operated tools designed to accommodate guards have guards installed.	☐	☐	☐	☐
17. Rotating or moving parts on tools are properly guarded.	☐	☐	☐	☐
18. Machines designed for fixed locations are secured or anchored.	☐	☐	☐	☐
19. Floor and bench-mounted grinders are provided with properly positioned work rests.	☐	☐	☐	☐
20. Guards are provided at point of operation, nip points, rotating parts, etc.	☐	☐	☐	☐
21. Fluid used in hydraulic-powered tools is approved fire-resistant fluid.	☐	☐	☐	☐
ELECTRIC-POWERED TOOLS (3.2.2)				
22. Electric tools are approved double insulated or grounded and used according to SOP HSE-206.	☐	☐	☐	☐
23. Electric cords are not used for hoisting or lowering tools.	☐	☐	☐	☐
24. Electric tools are used in damp/ wet locations are approved for such locations or GFCI installed.	☐	☐	☐	☐
25. Hand-held tools are equipped with appropriate on/off controls appropriate for the tool.	☐	☐	☐	☐
26. Portable, power-driven circular saws are equipped with proper guards.	☐	☐	☐	☐
ABRASIVE WHEEL TOOLS (3.2.3)				
27. All employees using abrasive wheel tools are wearing eye protection.	☐	☐	☐	☐
28. All grinding machines are supplied with sufficient power to maintain spindle speed.	☐	☐	☐	☐
29. Abrasive wheels are closely inspected and ring-tested before use.	☐	☐	☐	☐
30. Grinding wheels are properly installed.	☐	☐	☐	☐
31. Cup-type wheels for external grinding are protected by the proper guard or flanges.	☐	☐	☐	☐
32. Portable abrasive wheels used for internal grinding are protected by safety flanges.	☐	☐	☐	☐
33. Safety flanges are used only with wheels designed to fit the flanges.	☐	☐	☐	☐
34. Safety guards on abrasive wheel tools are mounted properly and of sufficient strength.	☐	☐	☐	☐
PNEUMATIC-POWERED TOOLS (3.2.4)				
35. Tools are secured to hoses or whip by positive means to prevent disconnection.	☐	☐	☐	☐
36. Safety clips or retainers are installed to prevent attachments being expelled.	☐	☐	☐	☐
37. Safety devices are installed on automatic fastener feed tools as required.	☐	☐	☐	☐
38. Compressed air is not used for cleaning unless reduced to < 30 psi, with PPE, and guarded.	☐	☐	☐	☐
39. Manufacturer's safe operating pressure for hoses, pipes, valves, etc. are not exceeded.	☐	☐	☐	☐
40. Hoses are not used for hoisting or lowering tools.	☐	☐	☐	☐
41. All hoses >1/2-inch diameter have safety device at source to reduce pressure upon hose failure.	☐	☐	☐	☐
42. Airless spray guns have required safety devices installed.	☐	☐	☐	☐
43. Blast cleaning nozzles are equipped with operating valves, which are held open manually.	☐	☐	☐	☐
44. Supports are provided for mounting nozzles when not in use.	☐	☐	☐	☐
45. Air receiver drains, handholes, and manholes are easily accessible.	☐	☐	☐	☐
46. Air receivers are equipped with drainpipes and valves for removal of accumulated oil and water.	☐	☐	☐	☐
47. Air receivers are completely drained at required intervals.	☐	☐	☐	☐
48. Air receivers are equipped with indicating pressure gauges.	☐	☐	☐	☐
49. Safety, indicating, and controlling devices are installed as required.	☐	☐	☐	☐
50. Safety valves are tested frequently and at regular intervals to assure good operating condition.	☐	☐	☐	☐

HS&E Self-Assessment Checklist—HAND AND POWER TOOLS

SECTION 2 (continued)

	Yes	No	N/A	N/O
LIQUID FUEL-POWERED TOOLS (3.2.5)				
51. Liquid fuel-powered tools are stopped when refueling, servicing, or maintaining.	☐	☐	☐	☐
52. Liquid fuels are stored, handled, and transported in accordance with SOP HSE-403	☐	☐	☐	☐
53. Liquid fuel-powered tools are used in confined spaces in accordance with SOP HSE-203.	☐	☐	☐	☐
54. Safe operating pressures of hoses, valves, pipes, filters, and other fittings are not exceeded.	☐	☐	☐	☐
POWDER-ACTUATED TOOLS (3.2.6)				
55. Only trained employee operates powder-actuated tools.	☐	☐	☐	☐
56. Powder-actuated tools are not loaded until just prior to intended firing time.	☐	☐	☐	☐
57. Tools are not pointed at any employee at any time.	☐	☐	☐	☐
58. Hands are kept clear of open barrel end.	☐	☐	☐	☐
59. Loaded tools are not left unattended.	☐	☐	☐	☐
60. Fasteners are not driven into very hard or brittle materials.	☐	☐	☐	☐
61. Fasteners are not driven into easily penetrated materials unless suitable backing is provided.	☐	☐	☐	☐
62. Fasteners are not driven into spalled areas.	☐	☐	☐	☐
63. Powder-actuated tools are not used in an explosive or flammable atmosphere.	☐	☐	☐	☐
64. All tools are used with correct shields, guards, or attachments recommended by manufacturer.	☐	☐	☐	☐
JACKING TOOLS (3.2.7)				
65. Rated capacities are legibly marked on jacks and not exceeded.	☐	☐	☐	☐
66. Jacks have a positive stop to prevent over-travel.	☐	☐	☐	☐
67. The base of jacks are blocked or cribbed to provide a firm foundation, when required.	☐	☐	☐	☐
68. Wood blocks are place between the cap and load to prevent slippage, when required.	☐	☐	☐	☐
69. After load is raised, it is cribbed, blocked, or otherwise secured immediately.	☐	☐	☐	☐
70. Antifreeze is used when hydraulic jacks are exposed to freezing temperatures.	☐	☐	☐	☐
71. All jacks are properly lubricated.	☐	☐	☐	☐
72. Jacks are inspected as required.	☐	☐	☐	☐
73. Repair or replacement parts are examined for possible defects.	☐	☐	☐	☐
74. Jacks not working properly are removed from service and repaired or replaced.	☐	☐	☐	☐
HAND TOOLS (3.2.8)				
75. Wrenches are not used when jaws are sprung to the point of slippage.	☐	☐	☐	☐
76. Impact tools are kept free of mushroomed heads.	☐	☐	☐	☐
77. Wooden handles of tools are kept free of splinters or cracks and are tightly fitted in tool.	☐	☐	☐	☐

HS&E Self-Assessment Checklist—HAND AND POWER TOOLS

SECTION 3

Complete this section for all items checked "No" in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: _____ Project Manager: _____

CH2MHILL

HS&E Self-Assessment Checklist: HEARING CONSERVATION

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI. This checklist is to be used at locations where CH2M HILL employees are required to wear hearing protection or are required to perform oversight of a subcontractor using hearing protection or both.

CH2M HILL staff shall not direct the means and methods of subcontractor use of hearing protection nor direct the details of appropriate corrective actions. The subcontractor must determine how to correct deficiencies and CH2M HILL staff must carefully rely on their expertise. Conditions considered to be imminently dangerous (possibility of serious injury or death) must be corrected immediately or all exposed personnel must be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to (check only one of the boxes below):

☐ Evaluate CH2M HILL compliance with its Hearing Protection program (SOP HSQ-108)
☐ Evaluate a CH2M HILL subcontractor's compliance with its Hearing Conservation program
Subcontractor's Name: _____

- Check "Yes" if an assessment item is complete or correct.

Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."

- Check "N/A" if an item is not applicable.

- Check "N/O" if an item is applicable but was not observed during the assessment.

SECTION 1	Yes	No	N/A	N/O
NOISE ASSESSMENT				
1. Employee must shout to converse – conduct hearing assessment				
2. A noise survey has been performed	☐	☐	☐	☐
3. All affected employees are included in the sampling strategy	☐	☐	☐	☐
4. Instruments used to conduct noise survey have been calibrated	☐	☐	☐	☐
5. Survey results have been provided to affected employees	☐	☐	☐	☐
6. The employer maintains copies of noise surveys for at least two years	☐	☐	☐	☐
GENERAL				
7. Hearing protection required if employee must shout to converse	☐	☐	☐	☐
8. Required hearing protection listed in HSP, FSI, or AHA	☐	☐	☐	☐
9. Hearing protection available for use by employees	☐	☐	☐	☐
10. Hearing protection stored appropriately to prevent deformation or distortion	☐	☐	☐	☐
11. Prior to insertion, users' hands/fingers are in a clean/sanitary condition	☐	☐	☐	☐
12. Hearing protection is maintained in a clean and sanitary condition	☐	☐	☐	☐
13. Damaged hearing protection is not used	☐	☐	☐	☐
14. Signs are posted warning employees of the areas requiring hearing protection	☐	☐	☐	☐

	Yes	No	N/A	N/O
NOISE ATTENTUATION cont.'				
15. After NRR is calculated, hearing protection chosen is appropriate for noise levels	☐	☐	☐	☐
16. If noise levels change, NRR is recalculated to ensure appropriate hearing protection is provided	☐	☐	☐	☐
ENGINEEERING CONTROLS				
17. Engineering controls can be used to minimize noise exposure to personnel	☐	☐	☐	☐
18. Are engineering management controls available to reduce the noise exposure	☐	☐	☐	☐
19. If technically/economically feasible, client authorizes implementation of engineering controls	☐	☐	☐	☐
ADMINISTRATIVE CONTROLS				
20. Employees can be rotated to further reduce exposure	☐	☐	☐	☐
21. Work assignments/tasks can be moved out of the high noise level areas	☐	☐	☐	☐
HEARING PROTECTION DEVICES				
22. Hearing protection selected is appropriate for the job	☐	☐	☐	☐
23. Hearing protection selected does not interfere with the task	☐	☐	☐	☐
24. Hearing protector seals are intact and have an effective seal on the users	☐	☐	☐	☐
25. Hearing protection selected fits the users	☐	☐	☐	☐
26. Hearing protection selected is appropriate for the job	☐	☐	☐	☐
27. Hearing protection selected attenuates noise to below 90 dBA	☐	☐	☐	☐
MEDICAL/AUDIOGRAMS				
28. All employees assigned to high noise areas have received their baseline audiogram	☐	☐	☐	☐
29. All employees assigned to high noise areas have received an annual audiogram	☐	☐	☐	☐
30. Has an employee suffered a standard threshold shift in their latest audiogram	☐	☐	☐	☐
TRAINING				
31. Employees have been provided with appropriate training regarding the effects of noise on hearing	☐	☐	☐	☐
32. Employees have been provided with appropriate training regarding the hearing protection devices	☐	☐	☐	☐
33. Employees have been provided with annual training indicating the purpose of hearing protectors	☐	☐	☐	☐
34. Affected employees have been provided with annual training.	☐	☐	☐	☐

SECTION 2

Complete this section for all items checked "No" in Section 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned or Taken	Date Corrected

Auditor: _____ Project Manager: _____

CH2MHILL

HS&E Self-Assessment Checklist: PPERSONAL PROTECTIVE EQUIPMENT

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where CH2M HILL employees are required to wear PPE or are required to perform oversight of a subcontractor using PPE or both.

CH2M HILL staff shall not direct the means and methods of subcontractor use of PPE nor direct the details of corrective actions. The subcontractor must determine how to correct deficiencies and CH2M HILL staff must carefully rely on their expertise. Conditions considered to be imminently dangerous (possibility of serious injury or death) must be corrected immediately or all exposed personnel must be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to (check only one of the boxes below):

☐ Evaluate CH2M HILL compliance with its PPE program (SOP HSE-117)
☐ Evaluate a CH2M HILL subcontractor's compliance with its PPE program
Subcontractor's Name: _____

Check the appropriate box, as follows:

- Check "Yes" if an assessment item is complete or correct.
- Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-121.

SECTION 1	**Yes**	**No**	**N/A**	**N/O**
GENERAL				
1. Required PPE listed in HSP FSI or AHA.	☐	☐	☐	☐
2. PPE available for use by employees.	☐	☐	☐	☐
3. PPE cleaning supplies available for use.	☐	☐	☐	☐
4. PPE stored appropriately to prevent deformation or distortion.	☐	☐	☐	☐
5. PPE written certification has been completed.	☐	☐	☐	☐
EYEWEAR (Glasses/Goggles/Face Shields)				
6 Eyewear cleaning supplies available.	☐	☐	☐	☐
7 Safety glasses in good condition and lenses free of scratches.	☐	☐	☐	☐
8 Goggles adjustment strap not cracked or frayed, not deformed, or lenses not scratched.	☐	☐	☐	☐
9. Face shields in good condition, including adjustment band, and free of scratches or chips.	☐	☐	☐	☐

SECTION 1 (Continued)	**Yes**	**No**	**N/A**	**N/O**
HEAD PROTECTION				
10. Hard hat bill and suspension attached as allowed by manufacturer.	☐	☐	☐	☐
11. Shell is pliable, free of dents, cracks, nicks, or any damage due to impact.	☐	☐	☐	☐
12. Suspension maintained at 1.25 inches from inside of shell.	☐	☐	☐	☐
13. Suspension free of cuts or fraying, torn headband, adjustment strap workable.	☐	☐	☐	☐
14. Electrical hard hat matched to hazard classification.	☐	☐	☐	☐
15. Dated to determine whether within manufacturer's allowable 5-year use time period.	☐	☐	☐	☐
HAND PROTECTION				
16. Available in sizes matched to employee.	☐	☐	☐	☐
17. Gloves free of rips tears, abrasions, or holes.	☐	☐	☐	☐
18. Matched to manufacturer's specification for chemicals used onsite.	☐	☐	☐	☐
19. Electrical gloves matched to hazard and periodically inspected for insulating rating.	☐	☐	☐	☐
20. Maintained in a clean and sanitary condition, decontaminated or disposed properly.	☐	☐	☐	☐
BODY PROTECTION				
21. Available in sizes matched to employee.	☐	☐	☐	☐
22. Maintained in a clean and sanitary condition, decontaminated or disposed properly.	☐	☐	☐	☐
23. Vapor-tight fully encapsulated suits tested at required periodic intervals.	☐	☐	☐	☐
24. Flame-resistant clothing matched to electrical hazard and arc flash rating.	☐	☐	☐	☐
25 Welding gear matched to degree of hazard and free of cuts, tears or burn holes.	☐	☐	☐	☐
26 Flotation gear available for work near or on water and in good condition.	☐	☐	☐	☐
HOT AND COLD BODY PROTECTION				
27 Cooling gear available based on degree of heat stress hazard.	☐	☐	☐	☐
28 Cooling gear in operable, clean, and sanitary condition.	☐	☐	☐	☐
29 Cold-weather gear provided based on needs assessment.	☐	☐	☐	☐
30. Cold-weather gear available in sizes to match employees.	☐	☐	☐	☐
31 Cold-weather gear is in free of tears, rips, or holes and in maintained in a clean condition.	☐	☐	☐	☐
TRAINING				
32 Initial PPE training completed by employees.	☐	☐	☐	☐
33 Training conducted when new types or styles of PPE are issued.	☐	☐	☐	☐
34 PPE selection, use, and maintenance reviewed at daily safety briefings.	☐	☐	☐	☐

SECTION 2

Complete this section for all items checked "No" in Section 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned or Taken	Date Corrected

Auditor: _____ Project Manager: _____

CH2MHILL

HS&E Self-Assessment Checklist –Non-Hazardous Waste

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI. This checklist is to be used at locations where CH2M HILL generate or manage non-hazardous waste.

CH2M HILL staff shall not direct the means and methods of subcontractor activities nor direct the details of appropriate corrective actions. The subcontractor must determine how to correct deficiencies and CH2M HILL staff must carefully rely on their expertise. Conditions considered to be imminently dangerous (possibility of serious injury or death) must be corrected immediately or all exposed personnel must be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM:

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL compliance with its Non-Hazardous Waste SOP (HSE-411)

☐ Evaluate a CH2M HILL subcontractor's compliance with non-hazardous waste procedures.

Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable
- Check "N/O" if an item is applicable but was not observed during the assessment

SECTION 1

	Yes	No	N/A	N/O
PROCEDURES				
SOURCE REDUCTION AND RECYLCING (5.1.1)				
1. Products have been re-used to reduce waste quantity and toxicity	☐	☐	☐	☐
2. Material volumes have been reduced by less packaging.	☐	☐	☐	☐
3. Less toxic products have been used to reduce waste toxicity.	☐	☐	☐	☐
4. Materials at CH2M HILL offices are recycled.	☐	☐	☐	☐
5. Recyclables generated at project sites are recycled.	☐	☐	☐	☐
STORAGE (5.2)				
6. Local or state solid waste storage requirements have been identified.	☐	☐	☐	☐
7. Local and state solid waste stockpile requirements have been identified.	☐	☐	☐	☐
8. Solid waste containers meet DOT specifications.	☐	☐	☐	☐
9. Non-hazardous waste label used for containers of non-hazardous waste.	☐	☐	☐	☐
DISPOSAL (5.3)				
Construction and Demolition Debris (5.3.1)				
10. Construction debris is disposed of at a landfill permitted to take C&D debris.	☐	☐	☐	☐
11. Clean C&D debris is reused.	☐	☐	☐	☐
12. C&D debris considered for recycling.	☐	☐	☐	☐
13. C&D debris containing hazardous waste is managed under HSE-408.	☐	☐	☐	☐

	Yes	No	N/A	N/O
Lead-Contaminated Waste (5.3.2)				
14. Lead-based paint debris managed under HSE-408 and HSE-413.	☐	☐	☐	☐
Petroleum-Contaminated Soil (5.3.3)				
15. REM consulted for treatment, disposal and recycling options for petroleum-contaminated soils.	☐	☐	☐	☐
Well Water Onsite Treatment and Discharge				
16. Non-hazardous well purge/development water treated in existing NPDES-permitted system.	☐	☐	☐	☐
17. Non-hazardous water is discharged to sewer untreated with POTW approval.	☐	☐	☐	☐
18. Non-hazardous waste is discharged to onsite wastewater pretreatment system.	☐	☐	☐	☐
19. Treatment of hazardous wastewater meets requirements of RCRA wastewater treatment unit.	☐	☐	☐	☐
Discharge at Offsite POTW/FOTW (5.3.4)				
20. Discharged water is classified using "client" knowledge and/or testing.	☐	☐	☐	☐
21. The water is not ignitable, does not contain organics or have an oily sheen.	☐	☐	☐	☐
22. Client provided written notice to POTW that water meets acceptance limits.	☐	☐	☐	☐
23. POTW discharge approval received in writing.	☐	☐	☐	☐
24. POTW EPA ID number obtained for hazardous wastewater.	☐	☐	☐	☐
25. Hazardous waste manifest used for transport of hazardous waste to POTW.	☐	☐	☐	☐
26. Waste meets pre-treatment requirements	☐	☐	☐	☐
Discharge to Injection Galleries/Injection Wells (5.3.4)				
27. Permit or approval obtained for discharge to injection gallery or well.	☐	☐	☐	☐
28. Purge water originated from wells at the site (same aquifer with same chemical properties).	☐	☐	☐	☐
29. The purge water is non-hazardous or exempt from hazardous waste regulations.	☐	☐	☐	☐
30. Injection gallery at site is operating under state permit or approval from EPA.	☐	☐	☐	☐
Discharge to Ground Surface (5.3.4)				
31. Discharged water is classified using "client" knowledge and/or testing.	☐	☐	☐	☐
32. Purge water is not a RCRA or state hazardous waste.	☐	☐	☐	☐
33. Written approval received from the client.	☐	☐	☐	☐
34. State permit or approval received for discharge.	☐	☐	☐	☐
35. Carbon filtration used prior to discharge to the ground surface.	☐	☐	☐	☐

SECTION 3

Complete this section for all items checked "No' in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: _____ Project Manager: _____

Project-specific Material Safety Data Sheets

Project-specific MSDSs will be added as chemicals are identified

MATERIAL SAFETY DATA SHEET

I - Product Identification

Product Identifier:

{ Fire Extinguisher ABC Multipurpose Dry Chemical

{ Fire Extinguisher Powder ABC Multipurpose

Chemical Name: ABC Dry Chemical (Mono-Ammonium Phosphate)

Chemical Family: Mixture Formula: $(NH_4)H_2PO_4$

Product Use:

Used in the application of extinguishing fires.

Manufacturer's Name and Telephone Number:

Flag Fire Equipment
Hwy #2 & Patillo Road, RR#1
Tecumseh, Ontario
N8N 2L9

Emergency Telephone: **519-727-6722**

Technical Information: 519-727-6722

II - Hazardous Ingredients

Name	%	Cas #	LD_{50}	LC_{50}
Silica Gel	0.12	112926-00-8	>4500 mg/kg/rat	>2 mg/hr/rat

Other Ingredients

Name	Cas #
Mono Ammonium Phosphate	7722-76-3
Tricalcium Phosphate	12167-74-7
Methyl Hydrogen Polysiloxane	63148-57-2

Fire Extinguishers contain compressed air to ensure a high velocity discharge of product. WHMIS Class A.

III - Physical Data

Physical State	Solid
Odour and Appearance	Yellow Crystal and odourless
Odour Threshold (ppm)	Not Applicable
Vapour Pressure (mm Hg)	Not Applicable
Evaporation Rate	None
Boiling Point (°C)	Not Applicable
Freezing Point (°C)	Not Applicable
pH	4.5 of 1% solution
Specific Gravity	Not Applicable
Solubility in Water	38 grams / 100 ml H_2O

IV - Fire and Explosion Data

Flashpoint (°C) and Method:	Non-flammable
Means of Extinction	None required
Upper Flammable Point	Not Applicable
Lower Flammable Point	Not Applicable
Auto Ignition Temperature (°C)	Not Applicable
Hazardous Combustion Products	None Known

Explosion Data

Sensitivity to Impact	Not Applicable
Sensitivity to Static Discharge	Not Applicable

V - Reactivity Data

† Yes Chemical Stability

† Yes Incompatibility with other substances

Conditions to avoid:

Do not mix with strong Alkalies

Hazardous Decomposition Products

Decomposes if heated above 121°C - 135°C
Ammonia, Carbon Monoxide and Oxides of Nitrogen are produced.

VI - Toxicological Properties

Route of Entry

† Skin Contact † Eye Contact † Inhalation
z Skin Absorption † Ingestion

Effects of Overexposure:

At high dust concentrations, irritation of eyes, skin and mucus membranes by chemical or mechanical action may occur.

Exposure Limits	Not Available
Irritancy of Product	Not Available
Sensitization to Product	Not Available
Carcinogenicity	None. Product is considered a nusisance dust. Silica Gel is a Synthetic Amorphous Silica which is considered a nuisance dust and no medical conditions are abnormally aggravated by this product.
Teratogenicity	None
Reproductive Toxicity	None
Mutagenicity	None
Synergistic Products	Not Available

VII - Preventative Measures

Gloves	None Required
Respirator	If in high dust concentration, wear a properly fitted NIOSH-approved dust respirator
Footwear	None Required
Clothing	None Specified
Eyewear	None Required

Engineering Controls

Adequate ventilation should be available to maintain dust levels below applicable standards on respirable and total nuisance dust. (at recharge stations only)

Leak and Spill Procedure

Ensure clean-up is performed by trained personnel only. Shovel or sweep up dry material for recycling or disposal. Flush residue with water.

Waste Disposal

Review federal, provincial/state, and local government requirements prior to disposal. Disposal by secure landfill may be acceptable.

Handling Procedures	Avoid container damage
Storage Requirements	Cool dry areas
Special shipping information	Fire Extinguisher Class 2.2 UN # 1044

VIII - First Aid Measures

Inhalation:	If breathing difficulty occurs because of dust inhalation, remove to fresh air.
Ingestion:	If person is conscious, give large amounts of water.
Eye Contact:	If eye irritation occurs, flush with copious amounts of water. Get medical attention if irritation persists.
Skin Contact:	Wash with mild soap and water.

IX - Preparation Date of MSDS

Prepared by Department: Health and Safety
Date: 01/01/2002

MSDS Control # 501-90MS

Fire Extinguisher ABC Multipurpose Dry Chemical

LIQUINOX MSDS

Section 1 : MANUFACTURER INFORMATION

Supplier: Same as manufacturer.

Manufacturer: Alconox, Inc.
30 Glenn St.
Suite 309
White Plains, NY 10603.

Manufacturer emergency phone number: 800-255-3924.
813-248-0585 (outside of the United States).

Manufacturer: Alconox, Inc.
30 Glenn St.
Suite 309
White Plains, NY 10603.

Supplier MSDS date: 2005/02/24

D.O.T. Classification: Not regulated.

Section 2 : HAZARDOUS INGREDIENTS

C.A.S.	CONCENTRATION %	Ingredient Name	T.L.V.	LD/50	LC/50
25155-30-0	10-30	SODIUM DODECYLBENZENESULFONATE	NOT AVAILABLE	438 MG/KG RAT ORAL 1330 MG/KG MOUSE ORAL	NOT AVAILABLE

Section 3 : PHYSICAL / CHEMICAL CHARACTERISTICS

Physical state: Liquid.

Appearance & odor: Odourless.
Pale yellow.

Odor threshold (ppm): Not available.

Vapour pressure (mmHg): @ 20°C (68°F).
17

Vapour density (air=1): >1

Volatiles (%)

By volume: Not available.

Evaporation rate (butyl acetate = 1): < 1.

Boiling point (°C):	100 (212F)
Freezing point (°C):	Not available.
pH:	8.5
Specific gravity @ 20 °C:	(water = 1). 1.083
Solubility in water (%):	Complete.
Coefficient of water\oil dist.:	Not available.
VOC:	None

Section 4 : FIRE AND EXPLOSION HAZARD DATA

Flammability:	Not flammable.
Conditions of flammability:	Surrounding fire.
Extinguishing media:	Carbon dioxide, dry chemical, foam. Water Water fog.
Special procedures:	Self-contained breathing apparatus required. Firefighters should wear the usual protective gear. Use water spray to cool fire exposed containers.
Auto-ignition temperature:	Not available.
Flash point (°C), method:	None
Lower flammability limit (% vol):	Not applicable.
Upper flammability limit (% vol):	Not applicable.

Not available.

Sensitivity to mechanical impact:	Not available.
Hazardous combustion products:	Oxides of carbon (COx). Hydrocarbons.
Rate of burning:	Not available.
Explosive power:	Containers may rupture if exposed to heat or fire.

Section 5 : REACTIVITY DATA

Chemical stability:	Product is stable under normal handling and storage conditions.
Conditions of instability:	Extreme temperatures.
Hazardous polymerization:	Will not occur.
Incompatible substances:	Strong acids. Strong oxidizing agents.
Hazardous decomposition products:	See hazardous combustion products.

Section 6 : HEALTH HAZARD DATA

Route of entry:	Skin contact, eye contact, inhalation and ingestion.
Effects of Acute Exposure	
Eye contact:	May cause irritation.
Skin contact:	Prolonged and repeated contact may cause irritation.
Inhalation:	May cause headache and nausea.
Ingestion:	May cause vomiting and diarrhea. May cause gastric distress.
Effects of chronic exposure:	See effects of acute exposure.
LD50 of product, species & route:	> 5000 mg/kg rat oral.
LC50 of product, species & route:	Not available.
Exposure limit of material:	Not available.
Sensitization to product:	Not available.
Carcinogenic effects:	Not listed as a carcinogen.
Reproductive effects:	Not available.
Teratogenicity:	Not available.
Mutagenicity:	Not available.
Synergistic materials:	Not available.
Medical conditions aggravated by exposure:	Not available.
First Aid	
Skin contact:	Remove contaminated clothing. Wash thoroughly with soap and water. Seek medical attention if irritation persists.
Eye contact:	Check for and remove contact lenses. Flush eyes with clear, running water for 15 minutes while holding eyelids open: if irritation persists, consult a physician.
Inhalation:	Remove victim to fresh air. If irritation persists, seek medical attention.
Ingestion:	Do not induce vomiting, seek medical attention. Dilute with two glasses of water. Never give anything by mouth to an unconscious person.

Section 7 : PRECAUTIONS FOR SAFE HANDLING AND USE

Leak / Spill:	Contain the spill. Prevent entry into drains, sewers, and other waterways. Wear appropriate protective equipment. Small amounts may be flushed to sewer with water. Soak up with an absorbent material. Place in appropriate container for disposal. Notify the appropriate authorities as required.
Waste disposal:	In accordance with local and federal regulations.
Handling procedures and equipment:	Protect against physical damage. Avoid breathing vapors/mists. Wear personal protective equipment appropriate to task.

Wash thoroughly after handling.
Keep out of reach of children.
Avoid contact with skin, eyes and clothing.
Avoid extreme temperatures.
Launder contaminated clothing prior to reuse.

Storage requirements: Store away from incompatible materials.
Keep containers closed when not in use.

Section 8 : CONTROL MEASURES

Precautionary Measures

Gloves / Type:

Wear appropriate gloves.

Respiratory / Type: None required under normal use.

Eye / Type:

Safety glasses recommended.

Footwear / Type: Safety shoes per local regulations.

Clothing / Type: As required to prevent skin contact.

Other / Type: Eye wash facility should be in close proximity.
Emergency shower should be in close proximity.

Ventilation requirements: Local exhaust at points of emission.

Olin
CHLOR ALKALI
PRODUCTS

MATERIAL SAFETY DATA

Hydrochloric Acid

SECTION 1 – CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Δ

Manufacturer's name and address:	**Supplier's name and address:**
Olin Corporation – Chlor Alkali Products Division	**PCI Chemicals Canada Company d/b/a Olin – Chlor Alkali Products**
CLEVELAND, TN OFFICE	**MONTREAL, QC OFFICE**
490 Stuart Road NE Cleveland, TN 37312-4918 U.S. • (423) 336-4850	2020 University, Suite 2190 Montreal, Quebec H3A 2A5 Canada • (514) 397-6100

Product Name: Hydrochloric Acid

CAS#: 7647-01-0 **Preparation date (M/D/Y):** 05/11/2010

MSDS Code: HCl-e **Revision date (M/D/Y):** 05/11/2010

Synonyms: Muriatic acid, Aqueous hydrogen chloride

Product Use: pH adjustment for water treatment, metal processing, sugar refining

Emergency Contacts (24 hr.)

FOR INFORMATION REGARDING ON SITE CHEMICAL EMERGENCIES INVOLVING A SPILL OR LEAK, CALL

Δ

Canada: 1-800-567-7455

U.S.: 1-800-424-9300 – CHEMTREC

SECTION 2 – COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Ingredient(s)	% (w/w)	ACGIH Ceiling (TLV-C) / OSHA / (PEL-C)	CAS NO.
Hydrogen chloride	20 – 40	ACGIH 2 ppm OSHA 5 ppm	7647-01-0

SECTION 3 – HAZARD IDENTIFICATION

Emergency Overview: Danger! Extremely corrosive! Causes severe burns and eye damage. Harmful if inhaled. Harmful or fatal if swallowed. Highly reactive with alkaline materials. Not flammable, but reacts with most metals to form explosive/flammable hydrogen gas. Read the entire MSDS for a more thorough evaluation of the hazards.

Potential Health Effects:

Δ **Routes of exposure:** Inhalation, skin contact, eye contact and ingestion.

General: Hydrochloric acid (HCl) is a very strong acid. Solutions can be extremely corrosive. The severity of effects depends on the concentration of the solution and the duration of contact. In general, HCl solutions and mists with a pH of 3 or less are a significant health concern.

Inhalation: Vapor or mist from concentrated solutions can cause severe nasal irritation, sore throat, choking, coughing and difficulty breathing (50-100 ppm). Prolonged exposures can cause burns and ulcers to the nose and throat. Severe exposures (e.g. 1000-2000 ppm), for even a few minutes, can cause a life-threatening accumulation of fluid in the lungs (pulmonary edema). Symptoms of pulmonary edema such as shortness of breath can be delayed for several hours after the exposure.

Skin Contact: Corrosive! Concentrated solutions may cause pain and deep and severe burns to the skin. Prolonged and repeated exposure to dilute solutions often causes irritation, redness, pain and drying and cracking of the skin.

Eye Contact: Immediate pain, severe burns and corneal damage, which may result in permanent blindness. Low concentrations of vapor or mist (10-35 ppm) can be immediately irritating, causing redness.

Ingestion: Causes severe irritation or corrosive burns to mouth, throat, esophagus and stomach. Symptoms may include difficulty in swallowing, intense thirst, nausea, vomiting, diarrhea and in severe cases, collapse and death.

Existing Medical Conditions Possibly Aggravated by Exposure: Skin irritation may be aggravated in individuals with existing skin lesions. Breathing of vapors or sprays (mists) may aggravate acute or chronic asthma and chronic pulmonary disease such as emphysema and bronchitis.

Chronic Effects: Repeated exposure to low concentrations of acid mist or vapor may cause redness, swelling and pain (dermatitis). Exposure to low concentration of acid mist or vapor by inhalation may cause bleeding of nose and gums, bronchitis, stomach pain (gastritis), and brownish discoloration and damage to tooth enamel. Dental erosion becomes more severe with increased exposure.

Carcinogenicity: Hydrochloric acid is not classified as carcinogenic by ACGIH (American Conference of Governmental Industrial Hygienists) or IARC (International Agency for Research on Cancer), not regulated as carcinogens by OSHA (Occupational Safety and Health Administration), and not listed as carcinogens by NTP (National Toxicology Program).

IARC Evaluation: There is inadequate evidence for the carcinogenicity in humans of hydrochloric acid. There is inadequate evidence for the carcinogenicity in experimental animals of hydrochloric acid. Overall evaluation: Hydrochloric acid is not classifiable as to its carcinogenicity to humans (Group 3).

Δ **Other important hazards:** Refer to TOXICOLOGICAL INFORMATION (Section 11) for additional information.

SECTION 4 – FIRST AID MEASURES

General: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential. SPEED IS ESSENTIAL. OBTAIN IMMEDIATE MEDICAL ATTENTION.

Inhalation: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Do not use mouth-to-mouth method if victim ingested or inhaled the substance: induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Give Cardiopulmonary Resuscitation (CPR) if there is no pulse AND no breathing. Obtain medical attention IMMEDIATELY. Symptoms may appear up to 48 hrs after exposure.

Skin Contact: Immediately flush skin with running water for a minimum of 20 minutes. Start flushing while removing contaminated clothing. If irritation persists, repeat flushing. Obtain medical attention

IMMEDIATELY. Do not transport victim unless the recommended flushing period is completed or flushing can be continued during transport.

While the patient is being transported to a medical facility, apply compresses of iced water. If medical treatment must be delayed, immerse the affected area in iced water. If immersion is not practical, compresses of iced water can be applied. Avoid freezing tissues.

Discard heavily contaminated clothing and shoes in a manner, which limits further exposure. Otherwise, wash clothing separately before reuse.

Eye Contact: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. Do not transport victim until the recommended flushing period is completed unless flushing can be continued during transport.

Ingestion: DO NOT INDUCE VOMITING. If victim is alert and not convulsing, rinse mouth and give 240 to 300 mL (8 to 10 oz.) of water to dilute material. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY contact local poison control center. IMMEDIATELY transport victim to an emergency facility. Never give anything by mouth if victim is rapidly losing consciousness, or is unconscious or convulsing.

SECTION 5 – FIRE FIGHTING MEASURES

Δ

Flash Point and method	Not applicable. Not combustible
Flammable Limits (Lower)	Not applicable
Flammable Limits (Upper)	Not applicable
Auto Ignition Temperature	Not applicable
Decomposition Temperature	Thermally stable up to temperatures of about 1500°C (2730°F).
Combustion and Thermal Decomposition Products	Hydrogen and chlorine
Rate of Burning	Not applicable
Explosive Power	Not sensitive
Sensitivity to Mechanical Impact	Not sensitive
Sensitivity to Static Discharge	Not sensitive
Fire and Explosion Hazards	Reacts with many metals to liberate hydrogen gas, which can form explosive mixtures with air. Hydrogen, a highly flammable gas, can accumulate to explosive concentrations inside drums, or any types of steel containers or tanks upon storage.
Extinguishing media	For large fires use extinguishing agents compatible with acid and appropriate for the burning material. An all purpose type AFFF foam may be used according to foam manufacturer's recommended techniques. The foam supplier should be consulted for recommendations regarding foam types and delivery rates for specific applications. Use carbon dioxide or dry chemical media for small fires. Do NOT use carbon dioxide, if cyanides are involved in fire. If only water is available, use it in the form of a fog.

Fire Fighting Procedures: As appropriate for surrounding materials/equipment. Water spray should be used to cool containers. Water spray may be used to knock down escaping vapor.

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and special protective clothing.

Evacuation: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

NOTE: Also see "Section 10 - Stability and Reactivity"

SECTION 6 – ACCIDENTAL RELEASE MEASURES

Spills, Leaks, or Releases:

- Restrict access to area until completion of clean up. Ensure trained personnel conduct clean up.
- Wear adequate personal protective equipment. Do not touch spilled material.
- Remove all ignition sources (no smoking, flares, sparks or flames). All equipment should be grounded. Ventilate area.
- Stop leak if possible without personal risk.
- Small spills: Cover with DRY earth, sand or other non-combustible material. Use clean non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal.
- Large spills: Isolate spill or leak area immediately for at least 50 meters (160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Prevent entry into sewers and confined areas. Dike with inert material (sand, earth, foamed polyurethane, foamed concrete, etc.). Consider in-situ neutralization and disposal. Absorb bulk liquid with fly ash or cement powder. Neutralize with recommended materials, taking care to avoid any foaming or splattering that may occur from the neutralization reaction of the acid with these materials. Make sure all liquid has been thoroughly contacted and absorbed by the dry materials. Transfer absorbed spill material and any contaminated underlying soil to a suitable chemical waste container. Ensure adequate decontamination of tools and equipment following clean up. Washing down of spills with water is not recommended as this tends to spread the contamination and increases the likelihood of percolating the acid down through the soil and/or of uncontrolled flow of acid into sewers, streams, or other waters. Hydrochloric acid leaks, or spills must not come in contact with any acid soluble sulfide wastes (such as sewers) because of the danger of evolving hydrogen sulfide gas.

  Comply with Federal, Provincial/State and local regulations on reporting releases.

Deactivating Chemicals: Lime, limestone, sodium carbonate (soda ash), sodium bicarbonate. The following absorbent materials have been tested and recommended for vapor suppression and/or containment of 26% and 35% hydrochloric acid solutions: a mixture of (75%) anionic polyacrylamide (R1779) and (25%) nonionic polyacrylamide (Versicol W25), individually use the anionic polyacrylamide or nonionic polyacrylamide, and Cellosize WP3H (hydroxyethyl cellulose).

Waste Disposal Methods: Dispose of waste material at an approved waste treatment/disposal facility, in accordance with applicable regulations. Do not dispose of waste with normal garbage or to sewer systems.

Note: - Clean-up material may be a RCRA Hazardous Waste on disposal.
- Spills are subject to CERCLA reporting requirements: RQ = 5000 lbs. (≈ 500 gal.; 2270 kg).

SECTION 7 – HANDLING AND STORAGE

Handling: Take all precautions to avoid personal contact. Prevent release of vapor or mist into workplace air. Always ensure adequate ventilation in handling areas. Locate safety shower and eyewash station close to chemical handling area. Inspect containers for leaks before handling. Use EXTREME care when diluting with water. Always add acid to water. CAUTION: Hydrogen, a highly flammable gas, can accumulate to explosive concentrations inside drums, or any types of steel containers or tanks upon storage. Storage containers should be vented on a regular basis by trained personnel ONLY. Label containers. Keep containers closed when not in use. Empty containers may contain residues, which are hazardous.

Storage: Store in a cool, dry, well ventilated area, out of direct sunlight and away from heat sources. Store away from incompatible materials such as oxidizing materials, reducing materials and strong bases. Use corrosion-resistant structural materials and lighting and ventilation systems in the storage area. Use containers, which are securely labeled and protected from damage. Storage drums must be coated with an acid resistant material. Rubber-lined steel, PVC/FRP, FRP, Hastelloy C-276, Inconel 625, and tantalum, are the most commonly used corrosion - resistant materials of construction at room temperature. Rubber, glass, plastic and ceramic ware are also resistant to corrosion. Vented containers must be used and must be kept closed when not being used. Containers should have a safety relief valve. Care should be taken to release any internal pressure slowly. Use corrosion-resistant transfer equipment when dispensing. Limit quantity of material in storage. Restrict access to storage area. Post warning signs when appropriate. Keep storage area separate from populated work areas. Inspect periodically for deficiencies such as damage or leaks.

Storage tanks should be above ground and surrounded with dikes capable of holding entire contents.

Storage Temperature: Exposure to extremes of heat and cold should be avoided. Ideal storage temperature is 10-27˚C (50-80.6˚F). Do not expose sealed containers to temperatures above 40˚C (104˚F).

Other Precautions: If stored indoors, building floors should be acid resistant with drains to a recovery tank. Electrical equipment should be flameproof and protected against corrosive action. Wood and other organic materials should not be used on floors, structural materials and ventilation systems in the storage area.

SECTION 8 – EXPOSURE CONTROLS / PERSONAL PROTECTION

PREVENTIVE MEASURES

Recommendations listed in this section indicate the type of equipment, which will provide protection against over exposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

Engineering Controls: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. The most effective measures are the total enclosure of processes and the mechanization of handling procedures to prevent all personal contact with hydrochloric acid. Because of the high potential hazard associated with this substance, stringent control measures such as enclosure or isolation are recommended when dealing with large quantities. Electrical installations should be protected against the corrosive action of acid vapors. Smoking should be prohibited in areas in which hydrochloric acid is stored or handled.

PERSONAL PROTECTIVE EQUIPMENT

Eye Protection: Wear splash resistant chemical goggles and full faceshield. Maintain eye wash fountain and quick-drench facilities in work area.

Skin Protection: Wear impervious protective clothing, including boots, gloves, lab coat, apron or full body suit, as appropriate, to prevent skin contact.

Recommended Materials: Guidelines for hydrochloric acid, 37%:

- RECOMMENDED (resistance to breakthrough longer than 8 hours): Butyl rubber, neoprene, Viton™, Saranex™, Barricade, CPF 3™, Responder™, Trellchem HPS™.
- RECOMMENDED (resistance to breakthrough longer than 4 hours): Natural rubber, nitrile rubber, polyvinyl chloride, Teflon™, 4H™ (polyethylene/ethylene vinyl alcohol).
- CAUTION, use for short periods only (resistance to breakthrough less than 1 hour): Polyethylene.
- NOT RECOMMENDED for use (resistance to breakthrough less than 1 hour): Polyvinyl alcohol.

Respiratory Protection:

Up to 50 ppm: Chemical cartridge respirator with cartridge(s) to protect against hydrogen chloride; or gas mask with canister to protect against hydrogen chloride or powered air-purifying respirator with cartridge(s) to protect against hydrogen chloride; or Supplied Air Respirator (SAR); or full-facepiece Self-contained breathing apparatus (SCBA).

EMERGENCY or planned entry into unknown concentration or IDLH conditions: Positive pressure, full-facepiece SCBA; or positive pressure, full-facepiece SAR with an auxiliary positive pressure SCBA.

ESCAPE: Gas mask with acid gas canister or escape-type SCBA.

EXPOSURE GUIDELINES

PRODUCT: Hydrochloric Acid:

ACGIH Ceiling Exposure Limit (TLV-C	2 ppm	(3 mg/m^3)
OSHA Ceiling Exposure Limit (PEL-C):	5 ppm	(7 mg/m^3)
NIOSH IDLH	50 ppm	

AIHA- Emergency Response Planning Guidelines (ERPGs)

ERPGs are for community emergency planning limits and not workplace exposure limits.

ERPG-1:	3 ppm
ERPG-2:	20 ppm
ERPG-3:	150 ppm

The **ERPG-1** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.

The **ERPG-2** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms, which could impair an individual's ability to take protective action.

The **ERPG-3** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects.

SECTION 9 – PHYSICAL AND CHEMICAL PROPERTIES

Alternate Name(s)	Hydrogen chloride, Muriatic acid
Chemical Name	Hydrochloric acid
Chemical Family	Inorganic acid
Molecular Formula	H-Cl
Molecular Weight	36.46
Δ **Physical State and Appearance**	Colorless, or slightly yellow liquid
Odor	Pungent odor
pH	Less than 1
Solubility (Water)	Miscible in all proportions in water
Solubility (Other)	Soluble in alcohol, ethers , benzene.
% Volatile by Volume	100
% Volatile Organic Compounds	Zero
Coefficient of OIL/Water Distribution	Not Available

BAUME	13°Be	18°Be	20°Be	22°Be	23°Be
Concentration	19.63	27.92	31.45	35.21	37.14
Vapor Pressure (mm Hg at 20°C)	0.3	11	20	72	150
Boiling Point (°C):	109	98	85	62	50
Melting Point (°C):	-55	-58	-40	-31	-27
Freezing Point (°C):	-55	-58	-40	-31	-27
Specific Gravity	1.10	1.14	1.16	1.18	1.19
Viscosity (cp at 20°C):	1.28	1.60	1.75	1.90	2.00

SECTION 10 – STABILITY AND REACTIVITY

Hazardous Decomposition Products: When heated to decomposition, emits toxic hydrogen chloride fumes. Thermal oxidative decomposition produces toxic chlorine fumes and explosive hydrogen gas.

Chemical Stability: Stable under conditions of normal use.

Conditions to Avoid: Avoid heat, flames, sparks and other sources of ignition.

Incompatibility with other Substances: A strong mineral acid, concentrated hydrochloric acid is incompatible with many substances and highly reactive with strong bases, metals, metaloxides, hydroxides, amines, carbonates and other alkaline materials. Incompatible with materials such as cyanides, sulfides, sulfites, sulfuric acid and formaldehyde. Contact with metals may produce flammable hydrogen gas. When diluting, add acid to water. Do NOT add water to the acid.

Hazardous Polymerization: Will not occur. Hydrochloric acid is a stable product and does not polymerize. However, it may induce hazardous polymerization with aldehydes and epoxides.

SECTION 11 – TOXICOLOGICAL INFORMATION

Δ For additional toxicological information, refer to Section 3.

TOXICOLOGICAL DATA:

Δ **Toxicological Data:**

LD_{50} (oral, rat) = 700 mg/kg

LD_{50} (dermal, rabbit) = >5010 mg/kg

LC_{50} (inhalation, rat) = 1562 ppm for 4 hr (3124 ppm for 1 hr)

LC_{50} (inhalation, mouse) = 1108 ppm/1 hr

Eye Effects (rabbit): Application of a 1% hydrochloric acid (0.25N) solution for 20 seconds caused scarring of the cornea. Other studies have reported that application of 5 mg for 30 seconds caused mild irritation, and that application of a 5% solution caused minimal irritation (duration not indicated).

Skin Effects (rabbit): Application of 0.5 mL of a 17% concentrated solution for 4 hours caused corrosive burns.

Δ **Sensitization to material:** Not expected to cause respiratory or skin sensitization reactions.

Mutagenicity: Mutagenic effects have been reported in one bacterial test (E. Coli-DNA repair), in three insect tests (Drosophila, grasshopper) and in one in vitro mammalian cell test (hamster lung cells). HCl was negative in another in vitro mammalian cell test (Syrian Hamster Embryo cells). The significance of the positive reports is questionable since pH (acidity) can influence the results of short-term tests.

Reproductive Effects: Female rats were exposed to 450 mg/m3 for 1 hour either prior to mating or on day 9 of pregnancy. Developmental effects were observed in the offspring. However, this exposure caused toxic effects, including mortality, in the mothers.

Teratogenicity and Fetotoxicity: No information is available.

Synergistic Materials: None known

SECTION 12 – ECOLOGICAL INFORMATION

Ecotoxicological Information:

Fish Toxicity: LC_{100} Trout 10 mg/L 24hr,
LC_{50} Shrimp 100 to 330 ppm/48 hr (salt water)
LC_{50} Gold fish 178 mg/L (one to two hours of survival time),
TLm/mosquito fish/ 282 ppm/96 hr/fresh water

The concentration of hydrochloric acid that was found to be injurious to crops is 350 mg/L.

Toxicity is primarily associated with pH. Toxic to aquatic life.

Invertebrate and Microbial Toxicity: Acidification of soy broth containing Listeria monocytogenes to pH 4.4 inhibited microbial activity.

Persistence and Degradation: When hydrochloric acid is spilled onto soil, it will begin to infiltrate. The presence of water in the soil will influence the rate of chemical movement in the soil. During transport through the soil, hydrochloric acid will dissolve some of the soil material, in particular those of a carbonate base. The acid will be neutralized to some degree. However, significant amounts of acid are expected to remain for transport down toward the ground water table. Hydrogen chloride in water dissociates almost completely, with the hydrogen ion captured by the water molecules to form the hydronium ion.

SECTION 13 – DISPOSAL CONSIDERATIONS

Review federal, state and local government requirements prior to disposal.

Do not dispose of waste with normal garbage, or to sewer systems.

Whatever cannot be saved for recovery or recycling, including containers, should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options.

RCRA: Test waste material for corrosivity, D002, prior to disposal.

SECTION 14 – TRANSPORT INFORMATION

	TDG CLR *	**DOT**
Shipping Name	Hydrochloric Acid	Hydrochloric acid
Hazard Class / Division	8	8
Identification No. **Packing Group:**	UN1789 II	UN1789 II
ERAP/ RQ	3000 L	RQ = 5000 lbs. (2270 Kg)

Note: * TDG CLR (Clear Language Regulations) became effective August 15, 2002

TDG – Emergency Response Assistance Plan (ERAP requirements of part 7 must be met for quantities exceeding 3000 liters per consignment.

Δ **IATA/ICAO Shipping Description:** UN1789, Hydrochloric acid, Class 8, PG II is accepted for air transport.

Δ **For Chemical Emergencies <u>in Transportation</u> Requiring Activation of Olin 24 Hour Emergency Response Plan Call:** **U.S. 1-800-424-9300 – Chemtrec**
Canada 1-800-567-7455

SECTION 15 – REGULATORY INFORMATION

Δ **CANADIAN INFORMATION:**

This product has been classified in accordance with the hazard criteria of the CPR (Controlled Products Regulations) and this MSDS (Material Safety Data Sheet) contains all the information required by the CPR.

Controlled Products Regulations (WHMIS) Classification:
Class D1A – Immediate and serious effects – Very Toxic
Class E – Corrosive

CEPA / Canadian Domestic Substances List (DSL): On the Canadian Domestic Substances List (CEPA DSL).

WHMIS Ingredient Disclosure List: Meets criteria for disclosure at 1% or greater.

National Pollutant Release Inventory (NPRI): Y

Δ **USA INFORMATION:**

OSHA Classification: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200)

SARA Regulations sections 313 and 40 CFR 372: Y

SARA Hazard Categories, SARA SECTIONS 311/312 (40 CFR 370.21):
ACUTE: Y
CHRONIC: N
FIRE: N
REACTIVE: N
SUDDEN RELEASE: Y
OSHA PROCESS SAFETY (29 CFR 1910.119): Y

CERCLA 40 CFR 302.4: Y
Reportable Quantity = 5000 lbs (2270 kg)

TSCA Inventory Status: Y

This product does not contain nor is it manufactured with ozone depleting substances.

Other Regulations/Legislation which apply to this product:
California Director's List of Hazardous Substances, Rhode Island Hazardous Substance List, New Jersey Environmental Hazardous Substance, Minnesota Hazardous Substance List, Massachusetts Extraordinarily Hazardous Substance, Florida Hazardous Substances List.

Right –To-Know: Illinois, Massachusetts, New Jersey, Pennsylvania

Δ **EUROPEAN ECONOMIC COMMUNITY (EEC) INFORMATION:**

EEC Classification: C, R 34 - 37

EINECS: 231-595-7

CALIFORNIA PROP 65 COMPONENTS:
This product is not listed, but it may contain elements known to the State of California to cause cancer or reproductive toxicity as listed under Proposition 65 State Drinking Water and Toxic Enforcement Act. For additional information, contact Olin Technical Services (800-299-6546)

SECTION 16 – OTHER INFORMATION

Δ **The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Olin will not be liable for any damages, losses, injuries or consequential damages that may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.**

Revision Indicators:
Δ In the left margin indicates a revision or addition of information since the previous issue.

National Fire Protection Association (NFPA) Rating
Hazardous Materials Identification System (HMIS) Rating

Δ

	NFPA	HMIS
HEALTH	3	3
FIRE	0	0
REACTIVITY / INSTABILITY	1	1
SPECIAL HAZARDS	N/Ap	N/Ap

4 = Extreme/Severe
3 = High/Serious
2 = Moderate
1 = Slight
0 = Minimum
~~W~~ = Water Reactive
OX = Oxidizer
* = Chronic health hazard

Δ **REFERENCES:**

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database, National Institute for Occupational Safety and Health, U.S. Dept. of Health and Human Services, Cincinnati, 2008
2. Transport Of Hazardous Materials (49CFR), Canadian Centre for Occupational Health and Safety, (2008)
3. "CHEMINFO", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada, (2008).
4. Chemlist, STN Database, Chemical Abstract Service, (2005)
5. Chemical Hazards Response Information System (CHRIS), CCOHS, (2008).
6. HSDB-Hazardous Substances Data Bank, through "CCINFO disc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada, (2008).
7. NFPA 49 Hazardous Chemicals Data 1994 Edition, National Fire Protection Association, Quincy, MA, 1994.
8. NIOSH POCKET GUIDE TO CHEMICAL HAZARDS, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, June 1997.
9. "2008 Threshold Limit Values and Biological Exposure Indices", American Conference of Government Industrial Hygienists, 2008.
10. TRANSPORT OF DANGEROUS GOODS (TDG), Canadian Centre for Occupational Health and Safety, (2008)

Δ **LEGEND**

ACGIH - American Conference of Governmental Industrial Hygienists
AFFF - Aqueous Film Forming Foam
AIHA - American Industrial Hygiene Association
CAS # - Chemical Abstracts Service Registry Number
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CFR - Code of Federal Regulations
DOT - Department of Transportation
EINECS - European Inventory of Existing Chemical Substances
EPA - Environmental Protection Agency
ERAP - Emergency Response Assistance Plan
IATA - International Air Transportation Association
ICAO - International Civil Aviation Organization
FRP - Fiberglass Reinforced Plastic
HMIS - Hazardous Materials Identification System
IARC - International Agency for Research on Cancer
IDLH - Immediately Dangerous to Life and Health
LC_{50} - The concentration of material in air expected to kill 50% of a group of test animals
LD_{50} - Lethal Dose expected to kill 50% of a group of test animals
MSHA - Mine Safety and Health Administration
N/Ap - Not Applicable
N/Av - Not Available
NFPA - National Fire Protection Association
NIOSH - National Institute for Occupational Safety and Health
NTP - National Toxicology Program
OSHA - Occupational Safety & Health Administration
PEL - Permissible Exposure Limit
PVC - Polyvinyl chloride
RCRA - Resource Conservation and Recovery Act
SARA - Superfund Amendments and Reauthorization Act of the U.S. EPA
STEL - Short Term Exposure Limit
TDG - Transportation of Dangerous Goods Act/Regulations
TLV - Threshold Limit Value
TSCA - Toxic Substances Control Act
TWA - Time Weighted Average
WEEL - Workplace Environmental Exposure Level
WHMIS - Workplace Hazardous Materials Identification System

Prepared by: Olin
(514) 397-6100

For the following RAE Part Numbers:

600-0001-000, 600-0002-000

600-0002-001, 600-0026-000

600-0027-000, 600-0069-000

AIR LIQUIDE™

MATERIAL SAFETY DATA SHEET

Prepared to U.S. OSHA, CMA, ANSI and Canadian WHMIS Standards

1. PRODUCT IDENTIFICATION

CHEMICAL NAME; CLASS: NONFLAMMABLE GAS MIXTURE

Containing One or More of the Following Components in a Nitrogen Balance Gas: Oxygen 0-23.5%; Isobutylene, 0.0005-0.9%

SYNONYMS: Not Applicable
CHEMICAL FAMILY NAME: Not Applicable
FORMULA: Not Applicable
Document Number: 50054

Note: The Material Safety Data Sheet is for this gas mixture supplied in cylinders with 33 cubic feet (935 liters) or less gas capacity (DOT - 39 cylinders). This MSDS has been developed for various gas mixtures with the composition of components within the ranges listed in Section 2 (Composition and Information on Ingredients). Refer to the product label for information on the actual composition of the product.

PRODUCT USE:	Calibration of Monitoring and Research Equipment
SUPPLIER/MANUFACTURER'S NAME:	CALGAZ
ADDRESS:	821 Chesapeake Drive Cambridge, MD 21613
EMERGENCY PHONE:	CHEMTREC: 1-800-424-9300
BUSINESS PHONE:	1-410-228-6400
General MSDS Information**:**	1-713/868-0440
Fax on Demand:	1-800/231-1366

2. COMPOSITION and INFORMATION ON INGREDIENTS

CHEMICAL NAME	CAS #	mole %	EXPOSURE LIMITS IN AIR					
			ACGIH-TLV		OSHA-PEL		NIOSH	OTHER
			TWA ppm	STEL ppm	TWA ppm	STEL ppm	IDLH ppm	ppm
Isobutylene	115-11-7	0.0005-0.9%	There are no specific exposure limits for Isobutylene.					
Oxygen	7782-44-7	0-23.5%	There are no specific exposure limits for Oxygen.					
Nitrogen	7727-37-9	Balance	There are no specific exposure limits for Nitrogen. Nitrogen is a simple asphyxiant (SA). Oxygen levels should be maintained above 19.5%.					

NE = Not Established. See Section 16 for Definitions of Terms Used.

NOTE (1): ALL WHMIS required information is included in appropriate sections based on the ANSI Z400.1-1998 format. This gas mixture has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: This is a colorless, odorless gas mixture. Releases of this gas mixture may produce oxygen-deficient atmospheres (especially in confined spaces or other poorly-ventilated environments); individuals in such atmospheres may be asphyxiated. Isobutylene, a component of this gas mixture, may cause drowsiness and other central nervous system effects in high concentrations; however, due to its low concentration in this gas mixture, this is unlikely to occur.

SYMPTOMS OF OVER-EXPOSURE BY ROUTE OF EXPOSURE: The most significant route of over-exposure for this gas mixture is by inhalation.

INHALATION: Due to the small size of an individual cylinder of this gas mixture, no unusual health effects from over-exposure to the product are anticipated under routine circumstances of use. The chief health hazard associated with this gas mixture is when this gas mixture contains less than 19.5% Oxygen and is released in a small, poorly-ventilated area (i.e. an enclosed or confined space). Under this circumstance, an oxygen-deficient environment may occur. Individuals breathing such an atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting, and depression of all the senses. Under some circumstances of over-exposure, death may occur. The effects associated with various levels of oxygen are as follows:

CONCENTRATION OF OXYGEN	OBSERVED EFFECT
12-16% Oxygen:	Breathing and pulse rate increase, muscular coordination slightly disturbed.
10-14% Oxygen:	Emotional upset, abnormal fatigue, disturbed respiration.
6-10% Oxygen:	Nausea, vomiting, collapse, or loss of consciousness.
Below 6%:	Convulsive movements, possible respiratory collapse, and death.

HEALTH EFFECTS OR RISKS FROM EXPOSURE: An Explanation in Lay Terms. Over-exposure to this gas mixture may cause the following health effects:

ACUTE: Due to the small size of the individual cylinder of this gas mixture, no unusual health effects from exposure to the product are anticipated under routine circumstances of use. The most significant hazard associated with this gas mixture when it contains less than 19.5% oxygen is the potential for exposure to oxygen-deficient atmospheres. Symptoms of oxygen deficiency include respiratory difficulty, ringing in ears, headaches, shortness of breath, wheezing, headache, dizziness, indigestion, nausea, unconsciousness, and death. The skin of a victim of over-exposure may have a blue color. Additionally, Isobutylene, a component of this gas mixture, may cause drowsiness or central nervous system effects in high concentrations; however, due to its low concentration in this gas mixture, this is unlikely to occur.

CHRONIC: Chronic exposure to oxygen-deficient atmospheres (below 18% oxygen in air) may affect the heart and nervous system.

TARGET ORGANS: ACUTE: Respiratory system, eyes. CHRONIC: Heart, cardiovascular system, central nervous system.

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH HAZARD	(BLUE)	1
FLAMMABILITY HAZARD	(RED)	0
PHYSICAL HAZARD	(YELLOW)	0

PROTECTIVE EQUIPMENT

EYES	RESPIRATORY	HANDS	BODY
See Section 8			

For Routine Industrial Use and Handling Applications

4. FIRST-AID MEASURES

RESCUERS SHOULD NOT ATTEMPT TO RETRIEVE VICTIMS OF EXPOSURE TO THIS GAS MIXTURE WITHOUT ADEQUATE PERSONAL PROTECTIVE EQUIPMENT. At a minimum, Self-Contained Breathing Apparatus must be worn.

No unusual health effects are anticipated after exposure to this gas mixture, due to the small cylinder size. If any adverse symptom develops after over-exposure to this gas mixture, remove victim(s) to fresh air as quickly as possible. Only trained personnel should administer supplemental oxygen and/or cardio-pulmonary resuscitation if necessary. Victim(s) who experience any adverse effect after over-exposure to this gas mixture must be taken for medical attention. Rescuers should be taken for medical attention if necessary. Take a copy of the label and the MSDS to physician or other health professional with victim(s).

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Acute or chronic respiratory conditions may be aggravated by over-exposure to this gas mixture.

RECOMMENDATIONS TO PHYSICIANS: Administer oxygen, if necessary; treat symptoms and eliminate exposure.

5. FIRE-FIGHTING MEASURES

FLASH POINT: Not applicable.

AUTOIGNITION TEMPERATURE: Not applicable.

FLAMMABLE LIMITS (in air by volume, %):

Lower (LEL): Not applicable.
Upper (UEL): Not applicable.

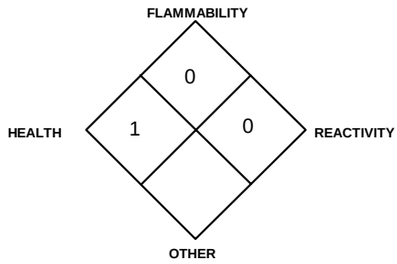
FIRE EXTINGUISHING MATERIALS: Non-flammable gas mixture. Use extinguishing media appropriate for surrounding fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: This gas mixture is not flammable; however, containers, when involved in fire, may rupture or burst in the heat of the fire.

Explosion Sensitivity to Mechanical Impact: Not sensitive.
Explosion Sensitivity to Static Discharge: Not sensitive.

SPECIAL FIRE-FIGHTING PROCEDURES: Structural firefighters must wear Self-Contained Breathing Apparatus and full protective equipment.

NFPA RATING



6. ACCIDENTAL RELEASE MEASURES

LEAK RESPONSE: Due to the small size and content of the cylinder, an accidental release of this gas mixture presents significantly less risk of an oxygen deficient environment and other safety hazards than a similar release from a larger cylinder. However, as with any chemical release, extreme caution must be used during emergency response procedures. In the event of a release in which the atmosphere is unknown, and in which other chemicals are potentially involved, evacuate immediate area. Such releases should be responded to by trained personnel using pre-planned procedures. Proper protective equipment should be used. In case of a leak, clear the affected area, protect people, and respond with trained personnel.

Allow the gas mixture to dissipate. If necessary, monitor the surrounding area (and the original area of the release) for oxygen. Oxygen levels must be above 19.5% before non-emergency personnel are allowed to re-enter area.

If leaking incidentally from the cylinder, contact your supplier.

7. HANDLING and USE

WORK PRACTICES AND HYGIENE PRACTICES: Be aware of any signs of dizziness or fatigue; exposures to fatal concentrations of this gas mixture could occur without any significant warning symptoms, due to oxygen deficiency. Do not attempt to repair, adjust, or in any other way modify the cylinders containing this gas mixture. If there is a malfunction or another type of operational problem, contact nearest distributor immediately.

STORAGE AND HANDLING PRACTICES: Cylinders should be firmly secured to prevent falling or being knocked-over. Cylinders must be protected from the environment, and preferably kept at room temperature (approximately 21°C [70°F]). Cylinders should be stored in dry, well-ventilated areas, away from sources of heat, ignition, and direct sunlight. Protect cylinders against physical damage. Full and empty cylinders should be segregated. Use a first-in, first-out inventory system to prevent full containers from being stored for long periods of time. These cylinders are not refillable. **WARNING! Do not refill DOT 39 cylinders. To do so may cause personal injury or property damage.**

SPECIAL PRECAUTIONS FOR HANDLING GAS CYLINDERS: WARNING! Compressed gases can present significant safety hazards. During cylinder use, use equipment designed for these specific cylinders. Ensure all lines and equipment are rated for proper service pressure.

PROTECTIVE PRACTICES DURING MAINTENANCE OF CONTAMINATED EQUIPMENT: Follow practices indicated in Section 6 (Accidental Release Measures). Make certain that application equipment is locked and tagged-out safely. Always use product in areas where adequate ventilation is provided.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION

VENTILATION AND ENGINEERING CONTROLS: No special ventilation systems or engineering controls are needed under normal circumstances of use. As with all chemicals, use this gas mixture in well-ventilated areas. If this gas mixture is used in a poorly-ventilated area, install automatic monitoring equipment to detect the levels of Nitrous Oxide and Oxygen.

RESPIRATORY PROTECTION: No special respiratory protection is required under normal circumstances of use. Maintain oxygen levels above 19.5% in the workplace. Use supplied air respiratory protection when oxygen levels are below 19.5%, or during emergency response to a release of this gas mixture. During an emergency situation, before entering the area, check the concentration of Methane and Oxygen. If respiratory protection is needed, use only protection authorized in the U.S. Federal OSHA Standard (29 CFR 1910.134), applicable U.S. State regulations, or the Canadian CSA Standard Z94.4-93 and applicable standards of Canadian Provinces. Oxygen levels below 19.5% are considered IDLH by OSHA. In such atmospheres, use of a full-facepiece pressure/demand SCBA or a full facepiece, supplied air respirator with auxiliary self-contained air supply is required under OSHA's Respiratory Protection Standard (1910.134-1998).

EYE PROTECTION: Safety glasses. If necessary, refer to U.S. OSHA 29 CFR 1910.133 or appropriate Canadian Standards.

HAND PROTECTION: Wear leather gloves when handling cylinders. Chemically resistant gloves should be worn when using this gas mixture. If necessary, refer to U.S. OSHA 29 CFR 1910.138 or appropriate Standards of Canada.

BODY PROTECTION: No special protection is needed under normal circumstances of use. If a hazard of injury to the feet exists due to falling objects, rolling objects, where objects may pierce the soles of the feet or where employee's feet may be exposed to electrical hazards, use foot protection, as described in U.S. OSHA 29 CFR 1910.136.

9. PHYSICAL and CHEMICAL PROPERTIES

The following information is for Nitrogen, a main component of this gas mixture.

GAS DENSITY @ 32°F (0°C) and 1 atm: 0.072 lbs/ ft^3 (1.153 kg/m^3)
BOILING POINT: -195.8°C (-320.4°F)
FREEZING/MELTING POINT @ 10 psig: -210°C (-345.8°F)
SPECIFIC GRAVITY (air = 1) @ 70°F (21.1°C): 0.906
pH: Not applicable.
SOLUBILITY IN WATER vol/vol @ 32°F (0°C) and 1 atm: 0.023
MOLECULAR WEIGHT: 28.01
EVAPORATION RATE (nBuAc = 1): Not applicable.
EXPANSION RATIO: Not applicable.
ODOR THRESHOLD: Not applicable.
SPECIFIC VOLUME (ft^3/lb): 13.8
VAPOR PRESSURE @ 70°F (21.1°C) psig: Not applicable.
COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

The following information is for Oxygen, a main component of this gas mixture.

GAS DENSITY @ 32°F (0°C) and 1 atm: 0.083 lb/cu ft (1.326 kg/m^3)
FREEZING/MELTING POINT @ 10 psig: -218.8°C (-361.8°F)
BOILING POINT: -183.0°C (-297.4°F)
SPECIFIC GRAVITY (air = 1) @ 70°F (21.1°C): 1.105
pH: Not applicable.
SOLUBILITY IN WATER vol/vol at 32°F (0°C) and 1 atm: 0.04.91
MOLECULAR WEIGHT: 32.00
EVAPORATION RATE (nBuAc = 1): Not applicable.
EXPANSION RATIO: Not applicable.
ODOR THRESHOLD: Not applicable.
VOLUME (ft^3/lb): 12.1
VAPOR PRESSURE @ 70°F (21.1°C) psig: Not applicable.
COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

The following information is for the gas mixture.

APPEARANCE AND COLOR: This is a colorless, odorless gas mixture.

HOW TO DETECT THIS SUBSTANCE (warning properties): There are no unusual warning properties associated with a release of this gas mixture. In terms of leak detection, fittings and joints can be painted with a soap solution to detect leaks, which will be indicated by a bubble formation.

10. STABILITY and REACTIVITY

STABILITY: Normally stable in gaseous state.
DECOMPOSITION PRODUCTS: The thermal decomposition products of Isobutylene include carbon oxides. The other components of this gas mixture do not decompose, per se, but can react with other compounds in the heat of a fire.
MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE: Titanium will burn in the Nitrogen component of this gas mixture. Lithium reacts slowly with Nitrogen at ambient temperatures. The Isobutylene component of this gas mixture is also incompatible with strong oxidizers (i.e. chlorine, bromine pentafluoride, oxygen difluoride, and nitrogen trifluoride).
HAZARDOUS POLYMERIZATION: Will not occur.
CONDITIONS TO AVOID: Contact with incompatible materials. Cylinders exposed to high temperatures or direct flame can rupture or burst.

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA: The following toxicology data are available for the components of this gas mixture:

ISOBUTYLENE:
LC_{50} (inhalation, rat) = 620,000 mg/kg/4 hours
LC_{50} (inhalation, mouse) = 415,000 mg/kg
NITROGEN:
There are no specific toxicology data for Nitrogen. Nitrogen is a simple asphyxiant, which acts to displace oxygen in the environment.

SUSPECTED CANCER AGENT: The components of this gas mixture are not found on the following lists: FEDERAL OSHA Z LIST, NTP, CAL/OSHA, and IARC; therefore, they are not considered to be, nor suspected to be, cancer-causing agents by these agencies.
IRRITANCY OF PRODUCT: Contact with rapidly expanding gases can be irritating to exposed skin and eyes.
SENSITIZATION TO THE PRODUCT: The components of this gas mixture are not known to cause human skin or respiratory sensitization.
REPRODUCTIVE TOXICITY INFORMATION: Listed below is information concerning the effects of this gas mixture and its components on the human reproductive system.

Mutagenicity: No mutagenicity effects have been described for the components in this gas mixture.
Embryotoxcity: No embryotoxic effects have been described for the components in this gas mixture.
Teratogenicity: No teratogenicity effects have been described for the components in this gas mixture.
Reproductive Toxicity: No reproductive toxicity effects have been described for the components in gas mixture.

A mutagen is a chemical which causes permanent changes to genetic material (DNA) such that the changes will propagate through generation lines. An embryotoxin is a chemical which causes damage to a developing embryo (i.e. within the first eight weeks of pregnancy in humans), but the damage does not propagate across generational lines. A teratogen is a chemical which causes damage to a developing fetus, but the damage does not propagate across generational lines. A reproductive toxin is any substance which interferes in any way with the reproductive process.
BIOLOGICAL EXPOSURE INDICES (BEIs): Currently, Biological Exposure Indices (BEIs) are not applicable for the components of this gas mixture.

12. ECOLOGICAL INFORMATION

ENVIRONMENTAL STABILITY: The components of this gas mixture occur naturally in the atmosphere. The gas will be dissipated rapidly in well-ventilated areas. The following environmental data are applicable to the components of this gas mixture.

OXYGEN: Water Solubility = 1 volume Oxygen/32 volumes water at 20°C. Log K_{ow} = -0.65
NITROGEN: Water Solubility = 2.4 volumes Nitrogen/100 volumes water at 0°C. 1.6 volumes Nitrogen/100 volumes water at 20°C.

EFFECT OF MATERIAL ON PLANTS or ANIMALS: No evidence is currently available on the effects of this gas mixture on plant and animal life.
EFFECT OF CHEMICAL ON AQUATIC LIFE: No evidence is currently available on the effects of this gas mixture on aquatic life.

13. DISPOSAL CONSIDERATIONS

PREPARING WASTES FOR DISPOSAL PREPARING WASTES FOR DISPOSAL: Waste disposal must be in accordance with appropriate Federal, State, and local regulations. Cylinders with undesired residual product may be safely vented outdoors with the proper regulator. For further information, refer to Section 16 (Other Information).

14. TRANSPORTATION INFORMATION

THIS GAS MIXTURE IS HAZARDOUS AS DEFINED BY 49 CFR 172.101 BY THE U.S. DEPARTMENT OF TRANSPORTATION.

PROPER SHIPPING NAME: Compressed gases, n.o.s. (*Oxygen, Nitrogen)*or the gas component with the next highest concentration next to Nitrogen.
HAZARD CLASS NUMBER and DESCRIPTION: 2.2 (Non-Flammable Gas)
UN IDENTIFICATION NUMBER: UN 1956
PACKING GROUP: Not applicable.
DOT LABEL(S) REQUIRED: Class 2.2 (Non-Flammable Gas)
NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2000): 126
MARINE POLLUTANT: The components of this gas mixture are not classified by the DOT as Marine Pollutants (as defined by 49 CFR 172.101, Appendix B).
SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure position, in a well-ventilated vehicle. The transportation of compressed gas cylinders in automobiles or in closed-body vehicles can present serious safety hazards. If transporting these cylinders in vehicles, ensure these cylinders are not exposed to extremely high temperatures (as may occur in an enclosed vehicle on a hot day). Additionally, the vehicle should be well-ventilated during transportation.
Note: DOT 39 Cylinders ship in a strong outer carton (overpack). Pertinent shipping information goes on the outside of the overpack. DOT 39 Cylinders do not have transportation information on the cylinder itself.

TRANSPORT CANADA TRANSPORTATION OF DANGEROUS GOODS REGULATIONS: This gas is considered as Dangerous Goods, per regulations of Transport Canada.

PROPER SHIPPING NAME: Compressed gases, n.o.s. (*Oxygen, Nitrogen)*or the gas component with the next highest concentration next to Nitrogen.
HAZARD CLASS NUMBER and DESCRIPTION: 2.2 (Non-Flammable Gas)
UN IDENTIFICATION NUMBER: UN 1956
PACKING GROUP: Not Applicable
HAZARD LABEL: Class 2.2 (Non-Flammable Gas)
SPECIAL PROVISIONS: None
EXPLOSIVE LIMIT AND LIMITED QUANTITY INDEX: 0.12
ERAP INDEX: None
PASSENGER CARRYING SHIP INDEX: None
PASSENGER CARRYING ROAD VEHICLE OR PASSENGER CARRYING RAILWAY VEHICLE INDEX: 75
NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2000): 126
NOTE: Shipment of compressed gas cylinders via Public Passenger Road Vehicle is a violation of Canadian law (Transport Canada Transportation of Dangerous Goods Act, 1992).

15. REGULATORY INFORMATION

ADDITIONAL U.S. REGULATIONS:
U.S. SARA REPORTING REQUIREMENTS: The components of this gas mixture are not subject to the reporting requirements of Sections 302, 304, and 313 of Title III of the Superfund Amendments and Reauthorization Act.
U.S. SARA THRESHOLD PLANNING QUANTITY: There are no specific Threshold Planning Quantities for this gas mixture. The default Federal MSDS submission and inventory requirement filing threshold of 10,000 lb (4,540 kg) may apply, per 40 CFR 370.20.
U.S. TSCA INVENTORY STATUS: The components of this gas mixture are listed on the TSCA Inventory.
U.S. CERCLA REPORTABLE QUANTITY (RQ): Not applicable.
OTHER U.S. FEDERAL REGULATIONS:

- No component of this gas mixture is subject to the requirements of CFR 29 1910.1000 (under the 1989 PELs).
- Isobutylene is subject to the reporting requirements of Section 112(r) of the Clean Air Act. The Threshold Quantity for this gas is 10,000 pounds.
- The regulations of the Process Safety Management of Highly Hazardous Chemicals are not applicable (29 CFR 1910.119).
- This gas mixture does not contain any Class I or Class II ozone depleting chemicals (40 CFR Part 82).

15. REGULATORY INFORMATION (continued)

- Nitrogen and Oxygen are not listed as Regulated Substances, per 40 CFR, Part 68, of the Risk Management for Chemical Releases. Isobutylene is listed under this regulation in Table 3 as Regulated Substances (Flammable Substances), in quantities of 10,000 lbs (4,554 kg) or greater.

U.S. STATE REGULATORY INFORMATION: The components of this gas mixture are covered under the following specific State regulations:

Alaska - Designated Toxic and Hazardous Substances: No.
California - Permissible Exposure Limits for Chemical Contaminants: Nitrogen.
Florida - Substance List: Oxygen, Isobutylene.
Illinois - Toxic Substance List: No.
Kansas - Section 302/313 List: No.
Massachusetts - Substance List: Oxygen, Isobutylene.
Michigan - Critical Materials Register: No.
Minnesota - List of Hazardous Substances: No.
Missouri - Employer Information/Toxic Substance List: No.
New Jersey - Right to Know Hazardous Substance List: Oxygen, Nitrogen, Isobutylene.
North Dakota - List of Hazardous Chemicals, Reportable Quantities: No.
Pennsylvania - Hazardous Substance List: Oxygen, Nitrogen, Isobutylene.
Rhode Island - Hazardous Substance List: Oxygen, Nitrogen.
Texas - Hazardous Substance List: No.
West Virginia - Hazardous Substance List: No.
Wisconsin - Toxic and Hazardous Substances: : No.

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65): No component of this gas mixture is on the California Proposition 65 lists.

ADDITIONAL CANADIAN REGULATIONS:
CANADIAN DSL/NDSL INVENTORY STATUS: The components of this gas mixture are listed on the DSL Inventory.
CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS: The components of this gas mixture are not on the CEPA Priorities Substances Lists.
CANADIAN WHMIS REGULATIONS: This gas mixture is categorized as a Controlled Product, Hazard Class A, as per the Controlled Product Regulations.

16. OTHER INFORMATION

INFORMATION ABOUT DOT-39 NRC (Non-Refillable Cylinder) PRODUCTS

DOT 39 cylinders ship as hazardous materials when full. Once the cylinders are relieved of pressure (empty) they are not considered hazardous material or waste. Residual gas in this type of cylinder is not an issue because toxic gas mixtures are prohibited. Calibration gas mixtures typically packaged in these cylinders are Nonflammable n.o.s., UN 1956. A small percentage of calibration gases packaged in DOT 39 cylinders are flammable or oxidizing gas mixtures.

For disposal of used DOT-39 cylinders, it is acceptable to place them in a landfill if local laws permit. Their disposal is no different than that employed with other DOT containers such as spray paint cans, household aerosols, or disposable cylinders of propane (for camping, torch etc.). When feasible, we recommended recycling for scrap metal content. CALGAZ will do this for any customer that wishes to return cylinders to us prepaid. All that is required is a phone call to make arrangements so we may anticipate arrival. Scrapping cylinders involves some preparation before the metal dealer may accept them. We perform this operation as a service to valued customers who want to participate.

MIXTURES: When two or more gases or liquefied gases are mixed, their hazardous properties may combine to create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you produce the mixture. Consult an Industrial Hygienist or other trained person when you make your safety evaluation of the end product. Remember, gases and liquids have properties which can cause serious injury or death.

Further information about the handling of compressed gases can be found in the following pamphlets published by: Compressed Gas Association Inc. (CGA), 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102. Telephone: (703) 412-0900.

P-1 *"Safe Handling of Compressed Gases in Containers"*
AV-1 *"Safe Handling and Storage of Compressed Gases"*
"Handbook of Compressed Gases"

PREPARED BY: CHEMICAL SAFETY ASSOCIATES, Inc.
PO Box 3519, La Mesa, CA 91944-3519
619/670-0609
Fax on Demand: 1-800/231-1366

AIR LIQUIDE™

Initial Medical Treatment Form

Initial Medical Treatment Form

To be completed by CH2M HILL Supervisor—Send with employee visiting medical facility or forward within 24 hours.

Employee name: _____
Date of Injury:_____
Supervisor: _____
HS Representative:_____
Visit Authorized by: _____
Phone #;_____

CH2M HILL Workers Compensation Administrator: Cambridge

Send Bills to: CH2M HILL
Attn: Jennifer Rindahl
P.O. Box 22508
Denver, Colorado 80222-0508

To be completed by medical provider:

Physician's name: _____ Phone #: _____
Address: _____
CH2M HILL employee: _____ has been treated for:_____

It is the policy of CH2M HILL to provide temporary modified duty whenever possible for employees with physical restrictions resulting from an occupational injury or illness.

☐ Released to full duty

☐ Released to restricted duty only (list restrictions below)

☐ Out of work until _____(date)

Please list any physical restrictions:

_____
_____

Expected duration of restricted duty? _____

CH2M HILL would like the best and most efficient care extended to all our employees. Please recommend over-the-counter (OTC) medication as a suitable alternative when medically feasible.

☐ Prescribed medication:_____

☐ Recommended OTC alternative:_____

Date of follow-up appointment:_____

Physician's signature: _____ Date: _____

Please return this form to the injured employee and FAX to Health Resources at 1-800-853-2641. If you want to discuss the employee's work restrictions, please call the person listed in the "Visit Authorized by" field

Project Activity Hazard Analyses

CH2MHILL

Insert AHAs

Pre-task Safety Plan

DAILY PRE-TASK SAFETY PLAN (PTSP)

Project: _____ Location: _____Date:_____

Site Safety Officer _____ Job Activity: _____

Task Personnel:

_____
_____
_____
_____

List Tasks:

_____
_____
_____
_____

Tools/Equipment/Materials required (ladders, scaffolds, fall protection, cranes/rigging, heavy equipment, power tools, cords, generators, compressed gases, regulated chemical products, etc.):

_____
_____
_____

Potential H&S Hazards, including chemical, physical, safety, biological and environmental (Check all that apply):

__ Chemical burns/contact	__ Trench, excavations, cave-ins	__Ergonomics
__ Pressurized lines/equipment	__ Overexertion	__ Chemical splash
__ Thermal burns	__ Pinch points	__ Poisonous plants/insects
__ Electrical	__ Cuts/abrasions	___Eye hazards/flying projectile
__ Weather conditions	__ Spills	__ Inhalation hazard
__Heights/fall> 6’	__ Overhead Electrical hazards	__ Heat/cold stress
__ Noise	__ Elevated loads	__ Water/drowning hazard
__ Explosion/fire	__ Slips, trip and falls	__ Heavy equipment
__Radiation	__ Manual lifting	__ Aerial lifts/platforms
__ Confined space entry	__Welding/cutting	__ Demolition

Other Potential Hazards (Describe):

_____
_____
_____

DAILY PRE-TASK SAFETY PLAN (PTSP)

Hazard Control Measures (Check all that apply):			
PPE __ Thermal/lined __ Eye __ Dermal/hand __ Hearing __ Respiratory __ Reflective vests __ Flotation device	**Protective Systems** __ Locate buried utilities __ Competent person __ Daily inspections __ Sloping __ Shoring __ Trench box __ Barricades	**Fire Protection** __ Fire extinguishers __ Fire watch __ Nonspark tools __ Grounding/bonding __ Intrinsically safe equipment __Combustible materials storage __Chemical Storage	**Electrical** __ Lockout/tagout __ Grounded __ Panels covered __ GFCI/extension cords __ Power tools/cord inspected __Insulated tools/gloves
Fall Protection __ Harness/lanyards __ Adequate anchorage __ Guardrail system __ Covered opening __ Fixed barricades __ Warning system	**Air Monitoring** __ PID/FID __ Detector tubes __ Radiation __ Personnel sampling __ LEL/O2 __ Other	**Proper Equipment** __ Aerial lift/ladders/scaffolds __ Forklift/ Heavy equipment __ Backup alarms __ Hand/power tools __ Crane w/current inspection __ Proper rigging __ Operator qualified	**Welding & Cutting** __ Cylinders secured/capped __ Cylinders separated/upright __ Flash-back arrestors __ No cylinders in CSE __ Flame retardant clothing __ Appropriate goggles
Confined Space Entry __ Isolation __ Air monitoring __ Trained personnel __ Permit completed __ Rescue provisions	**Medical/Emerg. Response** __ First-aid & BBP kit __ Eye wash __ FA-CPR training __ Route to hospital	**Heat/Cold Stress** __ Work/rest regime __ Rest area __ Liquids available __ Monitoring __ Training	**Vehicle/Traffic** __ Traffic Awareness __Traffic control __ Barricades __ Flags __ Signs
Permits __ Hot work __ Confined space __ Lockout/tagout __ Excavation __ Demolition __ Energized work __Local/Environmental	**Demolition** __ Pre-demolition survey __ Structure condition __ Isolate area/utilities __ Competent person __ Hazmat present	**Inspections** __ Ladders/aerial lifts __ Lanyards/harness __ Scaffolds __ Heavy equipment __Cranes and rigging __Other per Field Safety Plan	**Training** __ Hazwaste __ Construction __Equipment __ Competent person __ Task-specific (AHA) __ Hazcom
FieldNotes:_____ _____			

Supervisor signature:_____ Date:_____

Safe Work Observation Form

CH2MHILL

Safe Behavior Observation Form

☐ Federal ☐ Commercial ☐ International (check one)	☐ Construction or ☐ Consulting (check one)
Project Number (required):	Client/Program:
Project Name:	Observer: Date:
Position/Title of worker observed:	Background Information/ comments:
Task/Observation Observed:	

- ❖ Identify and reinforce safe work practices/behaviors
- ❖ Identify and improve on at-risk practices/acts
- ❖ Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- ❖ Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- ❖ Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	Safe	At-Risk	Observations/Comments
Current & accurate Pre-Task Planning/Briefing (Project safety plan, STAC, AHA, PTSP, tailgate briefing, etc., as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/qualified/experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/attentiveness			**Observer's Corrective Actions/Comments:**
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/Line of fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's Corrective Actions/Comments:**
Other…			

For ES Federal Sector projects please email completed forms to: CH2M HILL ES FED Safe Behavior Observation
For ES Commercial Sector projects please email completed forms to: CH2M HILL ES COM Safe Behavior Observation
For CNR ES staff please email completed forms to: cnressafe@ch2m.com
For International ES projects please e-mail completed forms to: ESINTLSafeBehaviorObservation@ch2m.com

Loss/Near-loss Investigation

Root Cause Investigation

This attachment is provided to assist in accessing, completing, and reviewing an incident investigation. It is important to remember the following when conducting an investigation:

- Gather relevant facts, focusing on fact-finding, not fault-finding.
- Draw conclusions, putting facts together into a probable scenario.
- Determine incident root cause(s), the basic causes why an unsafe act/condition existed.
- Develop and implement solutions, matching all identified root causes with solutions.

Documentation

The following should be included to document the incident.

Description

- Provide a description of the event and the sequence of events and actions that took place prior to the incident. Start with the incident event and work backwards in time through all of the preceding events that directly contributed to the incident. The information should identify why the event took place as well as who was involved, when and where the event took place, and what actions were taken.

Cause Analysis

Using the form and flowchart (provided below) the root cause of the incident will be determined. This form must be retained in the project and/or regional HSSE files.

Immediate Causes—List the substandard actions or conditions that directly affected the incident. The following are examples of immediate causes:

- ***Substandard Actions*:** Operating equipment without authority; failure to warn; failure to secure; operating at improper speed; making safety device inoperable; using defective equipment; failing to use PPE; improper loading; improper lifting; improper position for task; under influence of alcohol or drugs; horseplay.
- ***Substandard Conditions:*** Exposure to hazardous materials; exposure to extreme temperatures; improper lighting; improper ventilation; congestion; exposure to fire and explosive hazard; defective tools, equipment or materials; exposure to extreme noise; poor ventilation; poor visibility; poor housekeeping.

Basic Causes—List the personal and job factors that caused the incident. The following are examples of basic causes:

- ***Personal Factors:*** Capability; knowledge; skill; stress; motivation.
- ***Job Factors:*** Abuse or misuse; engineering; maintenance; purchasing; supervision; tools and equipment; wear and tear; work standards.

Corrective Action Plan

Include all corrective actions taken or those that should be taken to prevent recurrence of the incident. Include the specific actions to be taken, the employer and personnel responsible for implementing the actions, and a time frame for completion. Be sure the corrective actions address the causes. For example, training may prevent recurrence of an incident caused by a lack of knowledge, but it may not help an incident caused by improper motivation.

The following are examples of management programs that may be used to control future incidents. These programs should be considered when determining specific corrective actions:

- ***Management Programs***: Accident/incident analysis; emergency preparedness; engineering controls; general promotion; group meetings; health control; hiring and placement; leadership and administration; management training; organizational rules; personal protective equipment; planned inspections; program audits; program controls; purchasing controls; task analysis and procedures; task observation.

Incident & Near-Loss Investigation Report Form

Employer Information

Company Name: _____

Project Name: _____ Task Order: _____

Project Location: _____

Task Location: _____

Job Assignment: _____

Preparer's Name: _____ Preparer's Employee Number: _____

Incident Specific Information

Date of Incident: _____ Time of Incident: _____ a.m./p.m.

Location of incident:

☐ Company premises
☐ Field
☐ In Transit
☐ Other:_____

Address where the incident occurred: _____

Equipment Malfunction: Yes ☐ No ☐
Activity was a Routine Task: Yes ☐ No ☐

Describe any property damage: _____

Specific activity the employee was engaged in when the incident occurred:
_____
_____

All equipment, materials, or chemicals the employee was using when the incident occurred:
_____
_____

Describe the specific incident and how it occurred:
_____
_____
_____
_____
_____

Describe how this incident may have been prevented:

_____
_____
_____
_____

Contributing Factors (Describe in detail why incident occurred):

_____
_____
_____
_____

Date employer notified of incident: _____ To whom reported: _____

Witness Information (First Witness)

Name: _____
Employee Number_____
Address:_____
City: _____
Zip Code : _____
Phone: _____

Witness Information (Second Witness)

Name: _____
Employee Number_____
Address:_____
City: _____
Zip Code: _____
Phone: _____

Additional information or
comments:_____
_____
_____

A ROOT CAUSE ANALYSIS FORM MUST BE COMPLETED FOR ALL INJURIES AND ILLNESSES OR ACTUAL LOSSES.

COMPLETION OF THE ROOT CAUSE ANALYSIS FORM FOR NEAR LOSSES IS OPTIONAL, AT THE DISCRETION OF THE HEALTH AND SAFETY MANAGER.

Root Cause Analysis Form

Root Cause Analysis (RCA)

Root Cause Categories (RCC): In the first column, enter the appropriate RCC from the choices below that applies to the root cause (RC) and/or contributing factor (CF) of the incident. Describe the specific root cause and corrective actions in their respective columns.

1. **Lack of skill or knowledge**
2. **Lack of or inadequate operational procedures or work standards**
3. **Inadequate communication of expectations regarding procedures or work standards**
4. **Inadequate tools or equipment**
5. **Correct way takes more time and/or requires more effort**
6. **Shortcutting standard procedures is positively reinforced or tolerated**
7. **Person thinks there is no personal benefit to always doing the job according to standards**

RCC #	Root Cause(s)	Corrective Actions	RC[1]	CF[2]	Due Date	Completion Date	Date Verified

[1] RC = Root Cause; [2] CF = Contributing Factors (check which applies)

Investigation Team Members

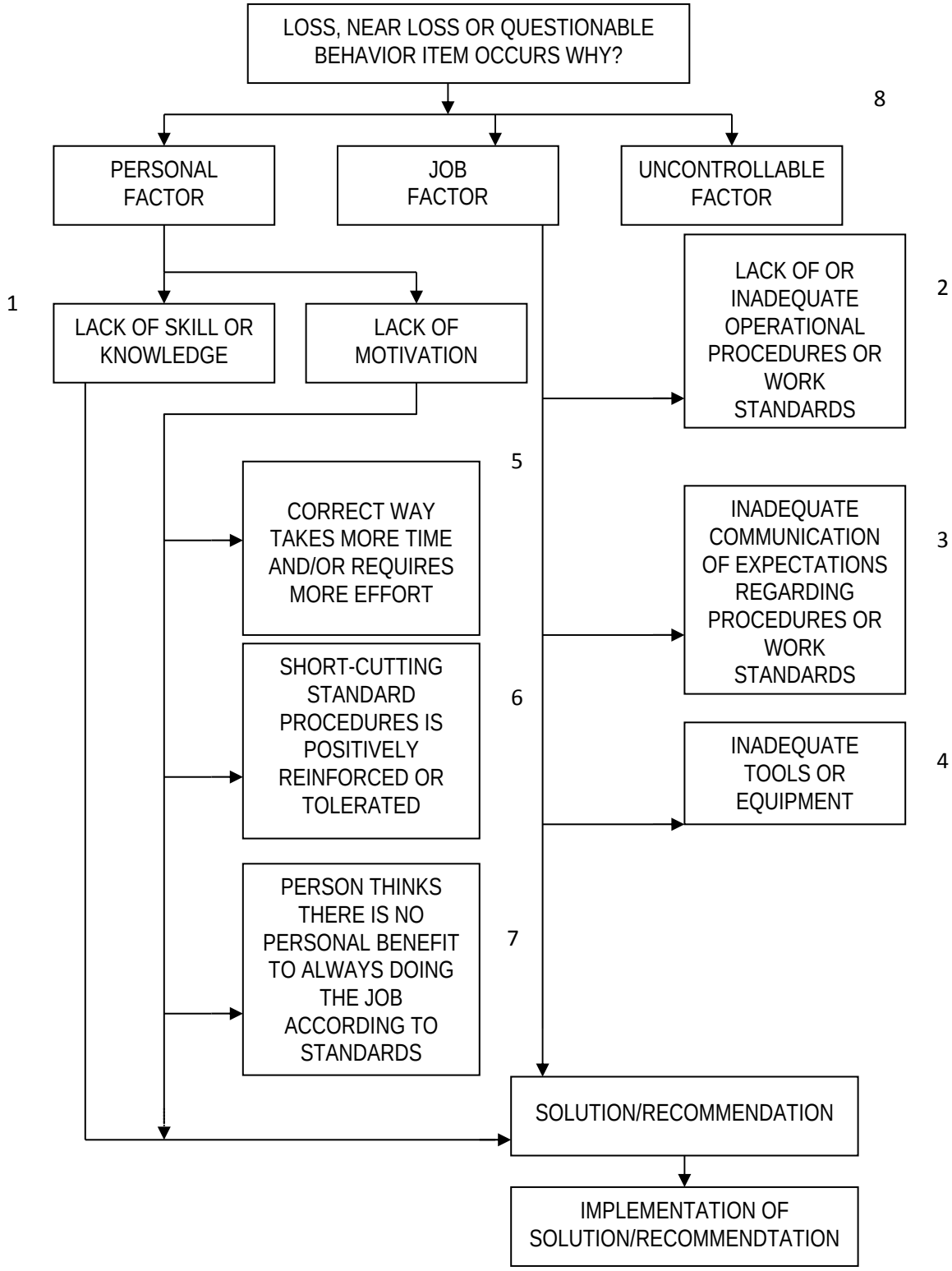
Name	Job Title	Date

Results of Solution Verification and Validation

Reviewed By

Name	Job Title	Date

Root Cause Analysis Flow Chart



Deficiency Tracking Log

CSIR Form

CLICK HERE FOR ATTACHMENTS

Permit Required Confined Space Entry
Enterprise Standard Operating Procedure HSE-203

1.0 Purpose

This Enterprise Standard Operating Procedure (SOP) outlines the requirements that CH2M HILL Legal Entities and Business Groups must comply with when performing Permit-required Confined Space Entry activities.

This SOP provides information regarding the potential hazards during Permit-required Confined Space Entry operations. Injuries and deaths can occur in confined spaces because of oxygen deficiency; the presence of materials that may be flammable, explosive, toxic, radioactive, or corrosive; engulfment by liquids, powders, or grains; and physical contact with energy sources including electrical, moving equipment, hot surfaces, hot air, or steam. If atmospheric pressure either greater than or less than normal is identified as a potential hazard, then additional safety requirements beyond the scope of this SOP will be required to protect the health and safety of personnel involved and to comply with regulations. All employees who enter Permit-required Confined Spaces must be aware of these hazards and of the associated safe work practices.

2.0 Scope and Application

This SOP applies Enterprise-Wide to all CH2M HILL Legal Entities and Business Groups, their employees, subcontractors and their lower-tier subcontractors that operate in the United States (U.S.) and internationally, unless a country-specific SOP is developed.

Some state's Occupational Safety and Health Administration (OSHA) plans may have more stringent requirements. Contact the appropriate Responsible Business Group (BG) Health and Safety Manager (HSM) to address these specific requirements. This SOP should be used as a starting point for international operations, but country-specific health and safety (H&S) regulations (e.g. Canada or Australia) shall prevail, and a country-specific SOP should be developed to comply with these specific H&S regulations.

This Enterprise SOP applies when:

- CH2M HILL employees enter permit-required confined spaces, regardless of the company responsible for confined space entry safety (CH2M HILL, subcontractor, or third party contractor) or when
- CH2M HILL provides oversight of subcontractor's Permit-required Confined Space Entry activities

Excavations are not considered confined spaces for the purpose of this SOP. Entry into excavations must comply with the requirements of the Excavation and Trenching SOP.

2.1 Applicable Enterprise SOPs

Other Enterprise SOPs that may be applicable to confined space entry activities include:

- HSE-121, ***Respiratory Protection***
- HSE-215, ***Contracts, Subcontracts, and HSE Management***
- HSE-307, ***Excavation and Trenching***
- HSE-308, ***Fall Protection***
- HSE-310, ***Lockout/Tagout***
- HSE-314, ***Welding and Cutting***

3.0 Definitions

3.1 Acceptable Entry Conditions

Acceptable entry conditions means the conditions that must exist in a Permit-required Confined Space to allow entry and to ensure that employees involved with a Permit-required Confined Space Entry can safely enter into and work within the space.

3.2 Atmospheric Hazards

Atmospheric hazards are conditions that may expose an individual to the risk of death, incapacitation, impairment, inability to self-rescue, injury, or acute illness from an oxygen-deficient or -enriched atmosphere; flammable or explosive conditions; or a toxic atmospheric environment.

3.3 Attendant or Standby Person

An Attendant or standby person is an individual positioned outside the confined space who monitors the Authorized Entrants and who fulfills the Attendant's responsibilities specified in section 4.7. The Attendant may also function in the role of the Entry Supervisor and perform all duties addressed in section 4.6.

3.4 Authorized Entrant

An Authorized Entrant is an individual authorized by the Entry Supervisor to enter a confined space.

3.5 Confined Space

A confined space is defined as a space that has **all** of the following characteristics:

- Large enough to allow personnel to enter the space with their entire body
- Limited openings for entry and exit
- Not designed for continuous human occupancy

Examples of possible confined spaces include underground vaults, pipelines, ducts, tunnels, digesters, storage tanks, sewers, silos, bins, boilers, bunkers, process vessels, ship holds, and pits.

3.6 Engulfment

Engulfment refers to the surrounding and effective capture of an individual by a liquid or finely divided solid substance that can be aspirated to cause death by filling or plugging the respiratory system, or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

3.7 Entrapment

Entrapment means the trapping or asphyxiating of an individual by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section.

3.8 Entry

Entry is defined as breaking the plane of a confined-space opening with any part of the body.

3.9 Entry Supervisor

An Entry Supervisor is the individual responsible for overseeing Confined Space Entry operations and who fulfills the Entry Supervisor's responsibilities specified in section 4.6. An Entry Supervisor may also serve as an Attendant or as an Authorized Entrant, as long as that individual can meet all the responsibilities of those positions.

3.10 Hazardous Atmosphere

An atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

- Flammable gas, vapor or mist in excess of 10 percent of its lower flammable limit (LFL)
- Airborne combustible dust at a concentration that meets or exceeds its LFL

  Note: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 meters) or less.

- Atmospheric oxygen concentrations below 19.5 percent (oxygen-deficient) or above 23.5 percent (oxygen-enriched)
- Atmospheric concentrations of any substance for which a dose or an OSHA Permissible Exposure Limit (PEL) is published that could result in employee exposure in excess of its dose or PEL

  Note: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.

- Any other atmospheric condition that is immediately dangerous to life or health

3.11 Immediately Dangerous to Life and Health (IDLH)

Immediately dangerous to life and health is any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or would interfere with an individual's ability to escape unaided from a permit space.

3.12 Limited Openings for Entry or Exit

Limited openings for entry or exit are those space openings that are configured or sized in a manner that presents a physical barrier, impeding self-rescue of an individual inside the space. Doorways and other openings that an individual can walk through are not generally considered limited means of entry or exit; however, they should be evaluated on a case-by-case basis to ensure that the space does not meet the definition of a confined space.

3.13 Non-atmospheric Hazards

Non-atmospheric hazards include engulfment and entrapment hazards, as well as other recognized serious safety or health hazards.

3.14 Non-permit Confined Space

A Non-permit Confined Space (NCS) is a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

3.15 Not Designed for Continuous Human Occupancy

A space not designed for continuous human occupancy is one that was not originally designed or subsequently redesigned to primarily provide for human health or safety (such as providing ventilation, lighting, means of access, and sufficient room to accomplish the anticipated task).

3.16 Other Serious Safety or Health Hazards

These may include exposure to radiation, electricity, moving parts, releases of energy, and material introduced into the space.

3.17 Permit-required Confined Space (permit space)

A Permit-required Confined Space (PRCS) means a confined space that has one or more of the following characteristics:

- Contains or has the potential to contain a hazardous atmosphere
- Contains a material that has the potential for engulfing an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section, or
- Contains any other recognized serious safety or health hazard

A PRCS also includes Alternate Entry Confined Spaces and PRCSs that are reclassified as a Non-permit Confined Space.

4.0 Roles and Responsibilities

The following sections outline the roles and responsibilities for individuals when using this procedure.

4.1 Business Group Health and Safety Leads

The BG H &S Leads are responsible for implementing this enterprise SOP for all projects in their BG. The BG H&S Lead also has the authority to approve deviation from this standard to accommodate local requirements.

4.2 Project Manager

The CH2M HILL Project Manager (PM) is responsible for providing adequate resources (budget and staff) for project-specific implementation of the H&S management process. The PM has overall H&S management responsibility, but may delegate specific tasks to other project staff. The PM retains ultimate H&S responsibility for the project.

4.3 Site Manager

The CH2M HILL Site Manager (SM) is responsible for all field operations onsite and is typically the Construction Manager (CM), Site Superintendent, Site Supervisor or Field Team Leader. The site manager is directly responsible for implementing all aspects of the project H&S plan, as assigned by the PM.

The site manager is responsible for the following confined space entry activities:

- Evaluating the specific tasks to determine whether the work can be completed without employees entering confined spaces
- Obtaining all available information regarding the space prior to entry
- Consulting with the Responsible BG Health and Safety Manager (RHSM) to identify hazards to classify the space and determine entry requirements
- Assigning an Entry Supervisor for each Permit-required Confined Space that will be entered by CH2M HILL employees
- Informing all affected CH2M HILL employees and subcontractor personnel of the location and hazards of the identified Permit-required Confined Spaces

4.4 Responsible Health and Safety Manager (RHSM)

The RHSM is the HSM assigned by the BG H&S Lead to provide health and safety technical guidance and support to the project. The RHSM prepares and/or approves the CH2M HILL project H&S plan, reviews subcontractor H&S plans and submittals, conducts project H&S audits, and provides H&S support and guidance to the project.

The RHSM is responsible for the following confined space entry activities:

- Performing risk assessment to identify hazards and determine entry requirements with assistance from the PM or SM
- Determining, with assistance from the PM/SM, the permit classification of confined spaces to be entered
- Providing any technical guidance to the Entry Supervisor as requested, prior to and during specific entries
- Reviewing subcontractor's Confined Space Entry procedures
- Verifying subcontractor's Entry Supervisor, Attendant, and Authorized Entrants qualifications and training documentation

4.5 Safety Coordinator

The Safety Coordinator (SC) is either the SM, or is designated by the SM to implement the project H&S Plan and who has successfully completed all required SC training.

The SC is responsible for the following confined space entry activities:

- Verifying Authorized Entrants, Attendant, and Entry Supervisor have completed CH2M HILL-required Confined Space Entry training for CH2M HILL Permit-required Confined Space Entry activities
- Reviewing the Confined Space Entry permits or certificates
- Reviewing cancelled permits and certificates to inform the RHSM of any concerns involving this SOP
- Providing field oversight of subcontractors entering confined spaces, and completing the self-assessment checklist for Confined Space Entry
- Suspending entry operations when a subcontractor is not following their Confined Space Entry procedures

4.6 Confined Space Entry Supervisor

Entry Supervisors are responsible for the following:

- Completing Confined Space Entry training
- Recognizing and evaluating the potential hazards that may be present during entry, then informing all entrants and attendants of these potential hazards, including the possible behavioral effects, signs and symptoms, and consequences of exposure
- Completing the applicable permit or certificate and verifying that the permit or certificate requirements have been met prior to authorizing entry
- Verifying that all Authorized Entrants and Attendants have completed Confined Space Entry training

- Assigning a confined space Attendant for each confined space that will be entered
- Verifying that effective communication methods are provided for Authorized Entrants and Attendants
- Conducting atmospheric monitoring or delegating this responsibility to a qualified individual
- Posting the permit or certificate at the opening to the space
- When supervising entry into a PRCS, verifying that rescue services are available and that the means for summoning them are operable
- Conducting a pre-entry briefing with all Authorized Entrants and Attendants to review the planned work and the requirements of the permit or certificate
- Documenting that PRCS reclassified as Non-permit Confined Space pose no actual or potential atmospheric hazard and all non-atmospheric hazards have been eliminated prior to entry
- Evacuating the space and suspending entry if any permit or certificate requirement is not met or if conditions change and present an actual or potentially dangerous situation
- Suspending entry if unauthorized entrants enter the space, and removing unauthorized entrants from the space
- Terminating the entry and canceling the permit or certificate when the work is completed
- Informing the owner of any hazards confronted or created in the space, or any problems encountered during entry
- Providing a copy of the canceled permit or certificate to the SC for the project H&S files.

4.7 Confined Space Attendant/Standby Person

Attendants/standby personnel are responsible for the following:

- Completing Confined Space Entry training
- Knowing the hazards that may be present during entry, including the possible behavioral effects and the modes, signs, symptoms, and consequences of exposure
- Communicating with the Authorized Entrants as appropriate to monitor entrant status
- Maintaining an accurate count of entrants in the space
- Remaining outside the permit space until relieved by another qualified Attendant, and performing no duties that might interfere with the Attendant's primary duty of monitoring the entrants
- Monitoring activities inside and outside the space to determine if it is safe for entrants to remain in the space

- Verifying that the Entry Supervisor has authorized entry, and that all requirements of the permit or certificate have been satisfied prior to allowing entry
- Verifying that the atmosphere has been tested at the frequency provided on the permit or certificate, verifying that the atmosphere is within acceptable safe levels, and documenting this testing on the permit or certificate
- Knowing how to use air monitoring equipment and interpret air monitoring instrument readings and alarms, and understanding the instrument's limitations
- Attending a pre-entry briefing prior to entry
- Performing non-entry rescues as specified on the Confined Space Entry Permit (CSEP)
- Maintaining rescue equipment at or near the confined space
- Summoning rescue and emergency services when entrants need assistance exiting the space
- Warning unauthorized persons to stay away from the space, and notifying the Entry Supervisor and entrants if unauthorized persons enter the space
- Evacuating entrants when a prohibited condition or dangerous situation is recognized, and when unable to perform attendant responsibilities
- Informing the Entry Supervisor of any hazards confronted or created in the space, or any problems encountered during entry
- Acting in the role of the Confined Space Entry Supervisor, as assigned

4.8 Confined Space Entrants

Entrants are responsible for the following:

- Completing Confined Space Entry training
- Knowing the hazards that may be present during entry, including the possible behavioral effects and the modes, signs, symptoms, and consequences of exposure
- Communicating with the Attendant as appropriate to enable the Attendant to monitor entrant status
- Verifying that the Entry Supervisor has authorized entry and that all requirements of the permit or certificate have been satisfied prior to allowing entry
- Verifying that the atmosphere has been tested at the frequency provided on the permit or certificate, and that the atmosphere is within acceptable safe limits and documented on the permit or certificate
- Attending a pre-entry briefing prior to entry
- Properly using the equipment required for entry
- Entering only the confined spaces that they are authorized to enter

- When using a Confined Space Alternate Procedure Certificate (APC), ensure that a buddy or an Attendant is positioned outside the space during entry
- Alerting the Attendant when a prohibited condition or dangerous situation is recognized
- Evacuating the space upon orders of the Attendant or Entry Supervisor when an alarm is sounded, or when a prohibited condition or dangerous situation is recognized
- Informing the Attendant or Entry Supervisor of any hazards confronted or created in the space, or any problems encountered during entry

4.9 CH2M HILL Employees

All employees are responsible for following safe work practices and complying with this SOP and project H&S requirements.

5.0 Requirements

The following PRCS requirements outlined in this Enterprise SOP must be implemented.

5.1 CH2M HILL Policy

It is the policy of CH2M HILL to avoid, whenever possible, employee entry into PRCSs. When entry cannot be avoided, all entries into confined spaces must be performed according to the requirements of this SOP. This SOP was developed to protect the health and safety of CH2M HILL employees and to comply with applicable regulations.

5.2 Permit-required Confined Space Program

The Permit-required Confined Space Program is CH2M HILL 's overall program for controlling, and where appropriate, for protecting employees from PRCS hazards and for regulating employee entry into such spaces.

5.2.1 Confined Space Identification

At client facilities, the PM/SM should consult the site owners to determine if there are any confined spaces within the CH2M HILL project area. All identified PRCSs within the project area must have a sign posted at the opening or entry point to warn all CH2M HILL employees, subcontractors, and site visitors. In addition to the signs, the PM/SM should also inform all CH2M HILL employees and subcontractors of the location of each identified PRCS, and that no person shall attempt to enter those spaces without the authorization of a permit or certificate.

5.2.2 Determine if Entry is Required

The PM/SM shall evaluate the specific tasks to be performed to determine whether the work can be completed without employees entering confined spaces. If entry is required, all available information should be obtained regarding the space including 1) blueprints of the space, 2) potential atmospheric and non-atmospheric hazards, and 3) identification of all

energy sources to assist in the risk assessment. The RHSM should be consulted early in the project planning to identify the hazards and determine the entry requirements.

5.2.3 Confined Space Evaluation/Classification

The RHSM, with assistance from the PM/SM and owner representative, shall determine if there are confined spaces on the project/client facility, along with the appropriate classification of any identified confined spaces that are required to be entered. For the purposes of this SOP, PRCSs are classified as one of the following:

- PRCS
- Alternate Procedure Confined Space
- PRCS reclassified as NCS

Attachment 1 provides a flowchart that should be used to classify confined spaces.

5.2.4 Permit-required Confined Space (PRCS)

A confined space is classified as a PRCS if **at least one** of the following characteristics exists:

- The space contains or has the potential to contain an atmospheric hazard (including oxygen-deficient atmospheres)
- The space contains material that has the potential for engulfment
- The space contains an internal design that has the potential for entrapment
- The space contains any other recognized serious safety or health hazard

PRCS entry requires the completion of a Confined-Space-Entry Permit as outlined in section 5.4.1.

5.2.5 Alternate Procedure Confined Space

PRCSs are classified as Alternate Procedure Confined Spaces if the only hazard within the space is an atmospheric hazard and the hazard can be controlled to acceptable safe levels solely by forced-air ventilation. If specific country requirements do not allow for classifying a space as an Alternate Procedure Confined Space, in accordance with the definition in this SOP, then all sections referencing alternative procedures do not apply. If the space must be entered in order to evaluate hazards, the initial entry must comply with PRCS entry requirements. Alternate Procedure Confined Space Entry requires the completion of an APC as outlined in section 5.4.2.

5.2.6 PRCS Reclassified as Non-permit Confined Space

A PRCS may be reclassified as a NCS when regulatory requirements allow for reclassification and if the space poses no actual or potential atmospheric hazard and if all non-atmospheric hazards can be eliminated without entry into the space. The PRCS may only be reclassified as a NCS for as long as the hazards remain eliminated. Non-atmospheric hazards may be eliminated through the cleaning and isolation methods described in sections 5.5.2 and 5.5.3, respectively.

The basis for determining that all hazards in a space have been eliminated must be confirmed and documented. If the space must be entered to eliminate non-atmospheric hazards, the initial entry must comply with PRCS entry requirements. The Non-permit Certificate (NPC) shall be completed by the Entry Supervisor prior to entry into a PRCS reclassified as NCS, as outlined in section 5.4.3.

When a PRCS has been reclassified as a NCS, any change in the conditions or activities from the original evaluation must be re-evaluated to determine if new hazards are created or existing controlled hazards are no longer controlled, which would warrant reclassifying the space as a PRCS or Alternate Procedure Confined Space.

5.3 Subcontractor Management

Subcontractor H&S responsibilities are expressly defined through the subcontract terms and conditions. Subcontractors must determine how to conduct their operations, in compliance with applicable H&S regulations and industry standards, and how to correct deficiencies. CH2M HILL employees shall not direct the means and methods of subcontractor operations.

Subcontractors are responsible and accountable for implementing these requirements and any additional requirements established in their own safety procedures. Subcontractors retain control over their practices, and CH2M HILL's oversight does not relieve them of their own responsibility for effective implementation and enforcement of HS&E requirements.

The "Subcontractor Safety Procedure Criteria—Permit-required Confined Space Entry" presented in Attachment 2 provides the minimum criteria for PRCS safety procedures. These criteria may be used by the Health Safety and Environment (HS&E) staff to review submitted PRCS safety subcontractor procedures when CH2M HILL is performing oversight of subcontractor's PRCS activities.

The "HS&E Self-Assessment Checklist—Permit-required Confined Space Entry" in Attachment 3 can be used to verify subcontractor's compliance with established safe work practices, regulations, and industry standards pertaining to PRCS Entry operations.

5.4 Permit-required Confined Space Entry Requirements

The following requirements apply when entering a PRCS, an Alternate Procedure Confined Space, or a PRCS to be reclassified as a NCS:

- Entrants, Attendants, and the Entry Supervisor shall have successfully completed Confined Space Entry training.
- A CSEP shall be completed as outlined in section 5.4.1, prior to entering a PRCS. A Confined-Space APC shall be completed as outlined in section 5.4.2, prior to entering an Alternate Procedure Confined Space. A Confined Space NPC shall be completed as outlined in section 5.4.3, prior to entering a PRCS that has been reclassified as a NCS.
- The completed permit or certificate shall be posted for review near the space entrance point.

- The Entry Supervisor shall conduct a pre-entry briefing with all Authorized Entrants and Attendants prior to entry in accordance with section 5.8.
- Entrants and Attendants shall verify that the Entry Supervisor has authorized entry and that all requirements of the permit or certificate have been satisfied prior to each entry.
- Atmospheric monitoring for oxygen, combustible gases, and potential toxic air contaminants shall be conducted at the frequency provided on the permit or certificate. Entry shall not be permitted if an atmospheric hazard is detected above acceptable safe levels. Atmospheric monitoring shall be performed in accordance with section 5.7.
- Entrants shall evacuate the space upon orders of the Attendant or Entry Supervisor, when an alarm is sounded, or when a prohibited condition or dangerous situation is recognized.
- Entrants and Attendants shall inform the Entry Supervisor of any hazards confronted or created in the space, or any problems encountered during entry. The Entry Supervisor shall inform the owner of such issues.
- The Entry Supervisor shall provide a copy of the canceled permit or certificate to the SC for review and maintain it in the project file for the period required as stated in section 8.0.

5.4.1 Confined Space Entry Permit (CSEP)

The CSEP provided in Attachment 4 shall be completed by the Entry Supervisor prior to entry into a PRCS. The following requirements apply to completing and using the CSEP:

- Entry may not be made or continued after the permit expiration date and/or time.
- All expected hazards of the confined space shall be listed on the CSEP.
- An Entry Supervisor shall be assigned to oversee all entry operations. Entry Supervisor responsibilities are provided in section 4.6.
- An Attendant shall be assigned with the fundamental responsibility of monitoring entrants. Attendant responsibilities are provided in section 4.7.
- Control measures used to reduce or eliminate hazards shall be listed on the CSEP. Additional details are provided in section 6.7.
- Communication and rescue procedures shall be identified on the CSEP and tested prior to entry. Additional details are provided in sections 5.5 and 5.6.
- Atmospheric monitoring requirements shall be identified on the CSEP. Additional details are provided in section 5.7.
- The SC shall review the CSEP and approve its use by signing the CSEP.
- The Entry Supervisor shall authorize entry by signing the CSEP.

- The Entry Supervisor shall document that all listed entrants in section 6.0 of the CSEP have completed confined-space training, have attended a pre-entry briefing, and are authorized to enter the space.
- Only individuals listed in section 6.0 of the CSEP shall be permitted to enter the space.
- The Entry Supervisor shall sign the CSEP indicating its cancellation.
- Problems encountered during the entry shall be listed on the CSEP.

5.4.2 Alternate Procedure Certificate (APC)

The APC provided in Attachment 5 shall be completed by the Entry Supervisor prior to entry into an Alternate Procedure Confined Space. The following requirements apply to completing and using the APC:

- Entry may not be made or continued after the certification expiration date and/or time.
- All expected atmospheric hazards of the confined space shall be listed on the APC.
- An Entry Supervisor shall be assigned to oversee all entry operations. Entry supervisor responsibilities are provided in section 4.6.
- An Attendant shall be assigned with the fundamental responsibility of monitoring entrants. Attendant responsibilities are provided in section 4.7.
- The Entry Supervisor shall verify that non-atmospheric hazards do not exist within the space.
- Communication methods shall be established between entrants and the Attendant.
- Entry covers shall be removed safely and openings guarded from both fall hazards and from objects entering the space.
- Continuous forced-air ventilation from a clean air source shall be positioned to ventilate the immediate areas where employees are working and shall continue until they have left the space. Ventilation shall be used in accordance with section 5.5.4.
- Atmospheric monitoring requirements shall be identified on the APC. Additional details are provided in section 5.7.
- The Entry Supervisor shall authorize entry by signing the APC.
- The Entry Supervisor shall document that all listed entrants in section 5.0 of the APC have completed confined-space training, have attended a pre-entry briefing, and are authorized to enter the space.
- Only individuals listed in section 5.0 of the APC shall be permitted to enter the space.
- The Entry Supervisor shall sign the APC indicating its cancellation.
- Problems encountered during the entry shall be listed on the APC.

5.4.3 Non-permit Certificate (NPC)

PRCSs may be reclassified as non-permit CS if they do NOT contain or do NOT have the potential to contain any hazard capable of causing death or serious physical harm. The PRCS may only be reclassified as a non-permit CS for as long as the hazards remain eliminated. The non-permit certificate (NPC) serves as documentation that the previously classified PRCS has been reclassified as a non-permit CS. Once a PRCS has been reclassified as a non-permit CS by completing the NPC, the space is no longer considered to be PRCS and no further NPCs are required to be completed for that space.

The NPC provided in Attachment 6 shall be completed by the Entry Supervisor prior to entering the space being reclassified from a PRCS to a non-permit CS to document the reclassification. The following is the process for reclassifying PRCS to non-permit CS using the NPC:

- An Entry Supervisor shall be assigned to oversee all entry operations. Entry Supervisor responsibilities are provided in section 4.6.
- An Attendant or buddy shall be assigned with the fundamental responsibility of monitoring entrants. Attendant responsibilities are provided in section 4.7. When a buddy is used, the buddy shall remain in the space with the entrant unless leaving to get emergency assistance.
- The Entry Supervisor shall verify that non-atmospheric hazards do not exist within the space.
- Communication methods shall be established between entrants and the Attendant or buddy.
- Entrants shall be informed to exit the space immediately if any hazards are observed.
- Atmospheric monitoring requirements shall be identified on the NPC. Additional details are provided in section 5.7.
- The Entry Supervisor shall authorize entry by signing the NPC.
- The Entry Supervisor shall document that all listed entrants in section 5.0 of the NPC have completed confined-space training, have attended a pre-entry briefing, and are authorized to enter the space.
- Only individuals listed in section 5.0 of the NPC shall be permitted to enter the space.
- The Entry Supervisor shall sign the NPC indicating its cancellation.
- Problems encountered during the entry shall be listed on the NPC.

If hazards arise while working in a non-permit CS that had been reclassified from a permit-required confined space (PRCS) using the NPC, personnel shall exit the space immediately. The space shall then be reevaluated to determine if it should be reclassified as a PRCS for future entries.

5.5 Control Measures

Control measures are the primary methods used for achieving acceptable entry conditions in a confined space. Control measures include communication, cleaning, isolation, ventilation, protective equipment, rescue equipment, and miscellaneous requirements. Additional information is provided below for each control measure.

5.5.1 Communications

Two-way communication must be maintained at all times between entrants and the Attendant. Communication systems may include visual, verbal, two-way radios, cellular phones, intercoms, closed-circuit video, continuous electronic monitoring equipment, alarm systems, and signaling systems.

5.5.2 Cleaning

Confined spaces shall be cleaned and decontaminated of hazardous materials to the extent feasible prior to entry. Where cleaning is not practical, appropriate personal protective equipment (PPE) shall be worn to provide protection from the hazards. The RHSM/HSM should be consulted for required PPE.

Purging, flushing, steaming, and pressure washing are methods of cleaning the space to eliminate or control atmospheric or chemical hazards.

Insertion of inert gases may be required to eliminate a flammable atmosphere. A noncombustible gas (such as nitrogen) is used to displace the flammable gas or vapor. The introduction of inert gases into the space may create an oxygen-deficient atmosphere, requiring further control measures to ensure the safety of the space.

Nozzles of air, inert gas, and steam line hoses, when used to clean spaces that contain flammable atmospheres, shall be bonded to the space. Bonding devices shall not be attached or removed in the presence of flammable concentrations.

5.5.3 Isolation

Confined spaces shall be isolated to remove them from service and completely protect against the release of energy and material into the space. Isolation methods include blanking or blinding, line breaking, double block and bleed, lockout or tagout, and blocking or disconnecting all mechanical linkages. Energy sources may include electrical, mechanical, hydraulic, pneumatic, chemical, thermal, radioactive, and the effects of gravity.

Blanking or blinding is a process that covers a pipe, line, or duct by fastening a solid plate that completely covers the bore and that is capable of withstanding the maximum upstream pressure.

Line breaking is a process that intentionally opens a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

Double block and bleed is a process that isolates the space from a line, duct, or pipe by locking or tagging two closed inline valves and locking or tagging open to the outside atmosphere a drain or bleed in the line between the two closed valves.

Lockout or tagout is a process that uses a lock, tag, or other device to physically remove sources of energy from a confined space.

Confined spaces that cannot be isolated because this may create a greater hazard, such as active sewers, must have detailed procedures as part of the CSEP that continually monitors inside and outside of the confined space for atmospheric and other hazards that pose a risk to entrants.

5.5.4 Ventilation

Confined spaces may require mechanical ventilation when atmospheric monitoring indicates that an atmospheric hazard exists above acceptable safe levels or when there is a potential for an atmospheric hazard to develop.

Continuous mechanical ventilation shall be maintained where flammable or toxic substances are used or when oxygen-consuming activities are performed as part of the scope of work (such as welding, painting, and use of solvents).

Electrically powered ventilation systems shall not be used for spaces that may contain a flammable atmosphere. Only explosion-proof ventilation systems (in the U.S., meeting the National Electric Code requirements for Class I, Division I locations) shall be used unless atmospheric monitoring has proven the existence of a non-explosive atmosphere.

Oxygen shall not be used to power air-driven ventilators or to ventilate any space location.

The following requirements apply to the use of mechanical ventilation systems:

- The air supply from forced-air ventilation systems shall originate from a clean source and may not increase the atmospheric hazards of the space
- Air intakes and exhausts shall be evaluated to avoid recirculating contaminated air
- Blowers, vents, or duct locations shall be placed and directed in a manner that will ventilate the immediate areas where entrants are present
- Loss of system efficiency shall be limited by using the shortest duct possible, maintaining tight connections, and keeping ducts as straight as possible
- The space shall be monitored for carbon monoxide if gasoline-powered ventilation systems are used

Nozzles of air hoses, when used to ventilate spaces that contain flammable atmospheres, shall be bonded to the space to dissipate potential static electricity buildup. Bonding devices must not be attached or removed if there is a potential presence of flammable vapor concentrations.

5.5.5 Protective Equipment

Confined spaces may require the following protective equipment:

- Air-powered tools should be used in lieu of electrical tools whenever possible.
- Ground fault circuit interrupters or earth leakage devices shall be used with all electrical appliances operated in a confined space.

- Electrical power tools shall be double insulated or grounded.
- When dangerous air concentrations may be attributable to flammable and/or explosive substances, lighting and electrical equipment shall be Class 1, Division 1-rated per National Electrical Code and no ignition sources shall be introduced into the area. In addition, spark-proof tools may be required. These shall be defined as necessary on the CSEP.
- Pedestrian, vehicle, and other barriers shall be provided to protect entrants from external hazards, as necessary.
- Respiratory protection may be required if other control measures do not reduce the atmospheric conditions to acceptable safe levels. Either an air-line respirator equipped with an escape bottle, or self-contained breathing apparatus shall be worn if an oxygen-deficient atmosphere exists. The RHSM shall be consulted before entering an oxygen-deficient atmosphere.
- Fall protection may be required if entrants are exposed to fall hazards.
- Spaces that contained substances corrosive to the skin or substances that can be absorbed through the skin may require the use of PPE. The RHSM shall be consulted for required PPE.

5.5.6 Rescue Equipment

Retrieval systems shall be used to facilitate non-entry rescue from PRCSs, unless the retrieval equipment increases the overall risk of entry or would not contribute to the rescue of entrants. Retrieval systems shall not be used for rescue under the following conditions:

- Obstructions or turns prevent the pull on the retrieval line from being transmitted to the entrant.
- The entrant being rescued with the retrieval system would be injured because of forceful contact with projections in the space.
- Retrieval lines of multiple entrants cannot be controlled so as to prevent entanglement hazards.
- Entrants are using air-supplied respirators and the retrieval lines cannot be controlled so as to prevent entanglement hazards with the air lines.

Retrieval systems shall meet the following requirements:

- Entrants shall wear a body harness with a retrieval line (lifeline) attached to the D-ring on the harness's back. Wristlets shall not be used unless it can be demonstrated that the use of a body harness is not feasible or creates a greater hazard, and that the use of wristlets is the most effective alternative.
- The other end of the lifeline shall be attached to the mechanical retrieval device (when required) or a fixed point outside the space so that non-entry rescue can begin as soon as the Attendant becomes aware that rescue is necessary.

- A mechanical retrieval device shall be positioned at the access point and be ready for use for all vertical-type spaces (access openings above the entrants head) that are 5 feet (1.5 meters) or greater in depth. Each entrant shall remain attached to a separate retrieval device during the entry.

5.5.7 Miscellaneous Equipment

The following miscellaneous requirements may pertain to certain confined spaces:

- Ladders may be required to provide safe ingress and egress to the space.
- A hot work permit may be required for operations in the space that are capable of providing a source of ignition.
- Work that involves the use of a flame, arc, sparks, or other source of ignition is prohibited within or adjacent to a space that contains, or has the potential to contain, a flammable atmosphere. This includes work in adjacent spaces having common walls, floor, or ceiling with the space at issue.
- When welding or cutting is performed inside the space, the gas cylinder and welding machine shall be positioned outside the space and local exhaust ventilation shall be required. The cylinders and welding machine must be positioned away from the air intake of the local exhaust ventilation system.
- Welding torches and leads shall be removed from the space when not in use.

5.6 Rescue and Emergency Procedures

One of the following rescue and emergency procedures shall be established and documented on the CSEP prior to PRCS entry:

- Non-entry retrieval system rescue
- Third-party rescue team
- CH2M HILL rescue team

The rescue that will be used on a specific project will be determined by the RHSM as part of developing the project-specific health and safety plan.

5.6.1 Non-entry Retrieval System Rescue

When non-entry rescue is feasible, retrieval systems shall be set up and used in accordance with this SOP. The Attendant(s) assigned to a specific confined space shall be familiar with the operation of the retrieval system and shall make at least one successful simulated rescue in which a dummy, mannequin, or actual person is rescued from the space. If the Attendant is unfamiliar with the specific type of retrieval system used for a confined-space entry, the Attendant must demonstrate their ability to properly use the system to the Entry Supervisor. The Attendant shall be trained in basic first aid and cardiopulmonary resuscitation (CPR) and hold a current certification card. Communication methods shall be established and tested between the Attendant and the local emergency medical provider and/or third-party rescue team (if necessary).

When non-entry rescue would increase the overall risk of entry or would not contribute to the rescue of entrants, a third-party or CH2M HILL rescue team shall be established.

5.6.2 Third-Party Rescue Team

Third-party rescue teams shall not be used without approval from the RHSM.

Third-party rescue teams include any team comprised of employees other than CH2M HILL employees and may include a client, contractor, subcontractor, local emergency response organization, or independent rescue team. All third-party rescue teams shall be evaluated by the RHSM to determine their ability to provide proficient rescue services and their ability to respond in a timely manner, based on the specific hazards involved with the entry. The RHSM shall also verify that the rescue team is trained, equipped, able and willing to provide rescue services.

The requirements of section 5.6.3 also apply to third-party rescue teams. In addition, these teams shall be provided access to all spaces from which rescue may be necessary so that the teams can develop rescue plans and practice operations.

5.6.3 CH2M HILL Rescue Team

The following requirements apply to a confined-space rescue team made up of CH2M HILL employees:

- The RHSM must approve the use of a CH2M HILL rescue team.
- Team members must complete Confined Space Entry training.
- Team members shall be informed of the hazards that they may confront during rescue operations.
- All PPE and rescue equipment necessary to conduct a safe-entry rescue shall be provided and must be readily available.
- Team members shall be trained on rescue responsibilities and the proper use of PPE and rescue equipment to be used on the specific confined-space entry.
- All team members shall be trained in basic first aid and CPR, with at least one team member holding a current certification card.
- The rescue team shall have made at least one simulated rescue in which a dummy, mannequin, or actual person is rescued from a space of similar configuration within the last 12 months.
- Communication methods shall be established and tested between the rescue team and entrants, and the local emergency medical provider. The local emergency medical provider shall be notified in advance of entries into the PRCS.

5.7 Atmospheric Monitoring

All confined spaces shall be monitored for atmospheric hazards. The entry supervisor shall conduct the atmospheric monitoring, or delegate this responsibility to a qualified individual. To be considered qualified, the individual must know how to calibrate and

operate the atmospheric monitoring instruments, interpret readings and alarms, and understand the instrument limitations.

The CSEP, APC, or NPC shall provide the frequency at which monitoring shall take place, the types of instruments to be used, and the substances to be monitored. All monitoring results shall be documented on the CSEP, APC, or NPC. Employees shall not enter a confined space until all monitoring requirements are completed.

The following requirements apply to atmospheric monitoring:

- Atmospheric monitoring equipment shall be field-calibrated prior to use. The equipment manufacturer's periodic calibration recommendations shall be followed.
- Atmospheric monitoring must be completed in the following sequence:
  - Oxygen (percent O_2 by volume)
  - Flammability [percent of the lower explosive limit (LEL)]
  - Toxic air contaminants (actual concentration)
  - Toxic dusts (actual concentration, if necessary)
- Atmospheric samples shall be taken from outside the space, with sampling conducted bottom to top at 5-foot intervals. Gases and vapors have different vapor densities and will accumulate in different areas of the space.
- All monitoring results shall be documented on the CSEP, APC, or NPC.
- Flammable and combustible vapors in concentrations greater than 10 percent of the LEL will require the use of continuous monitoring

5.8 Pre-entry Briefing

A pre-entry briefing specific to the confined space to be entered is required prior to entering that confined space. The Entry Supervisor shall conduct the briefing, and all entrants and Attendants must attend. The briefing must include at least the following elements:

- An explanation of the work to be performed, and any limitations
- An explanation of the actual and potential hazards of the confined space, including the possible behavioral effects and signs, symptoms, and consequences of exposure
- A review of the control measure requirements, communication and rescue procedures, and atmospheric monitoring requirements, as specified on the CSEP, APC, or NPC
- A review of the specific responsibilities of the entrants and Attendant as specified in sections 4.7 and 4.8, respectively

Hands-on training shall be provided to employees who are not familiar with the use of relevant equipment.

6.0 Training Requirements

Employees who enter PRCSs, or who act as the Confined Space Entry Supervisor or Attendant are required to complete a CH2M HILL-required, classroom-based Confined Space Entry Training Program. The CH2M HILL Confined Space Entry Training Program shall be used to the extent possible and supplemented with individual country requirements where applicable.

Employees who are assigned to a Confined Space Entry rescue team must complete the training specified by the RHSM in the site-specific written H&S plan and section 5.6.3 of this SOP prior to the start of the Confined Space Entry activities on the project.

Subcontractors entering confined spaces are responsible for complying with all applicable HS&E training requirements and for providing the training necessary to complete their tasks safely.

7.0 Assessment Requirements

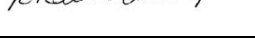
The "HS&E Self-Assessment Checklist—Permit-required Confined Space Entry" is provided in Attachment 3 as a method for verifying compliance with this SOP. The RHSM may use this checklist when performing H&S audits at CH2M HILL projects, including subcontractor's activities.

8.0 Recordkeeping

Canceled entry permits shall be retained in the project files for 1 year by the PM or designee. Review of the canceled permits at the time of receipt by the SC or over a period of time shall determine if any improvements or changes are necessary to this SOP.

Training certificates will be maintained for the duration of employment.

9.0 Revision Log

Revision	Date	Description:	Prepared By	Approved By:
1.0	09/05/2006	Updated from Standard of Practice to Standard Operating Procedure.	Angelo Liberatore/ Mark Fagan	
2.0	01/13/2010	Clarified section 5.4.3, Non Permit Certificate (NPC) on requirements for reclassifying PRCS to non-permit CS.	Angelo Liberatore/ Stephanie DeWitt	

10.0 Attachments

Attachment 1: **Confined Space Classification Flowchart**

Attachment 2: **Subcontractor Safety Procedure Criteria—Permit-required Confined Space Entry**

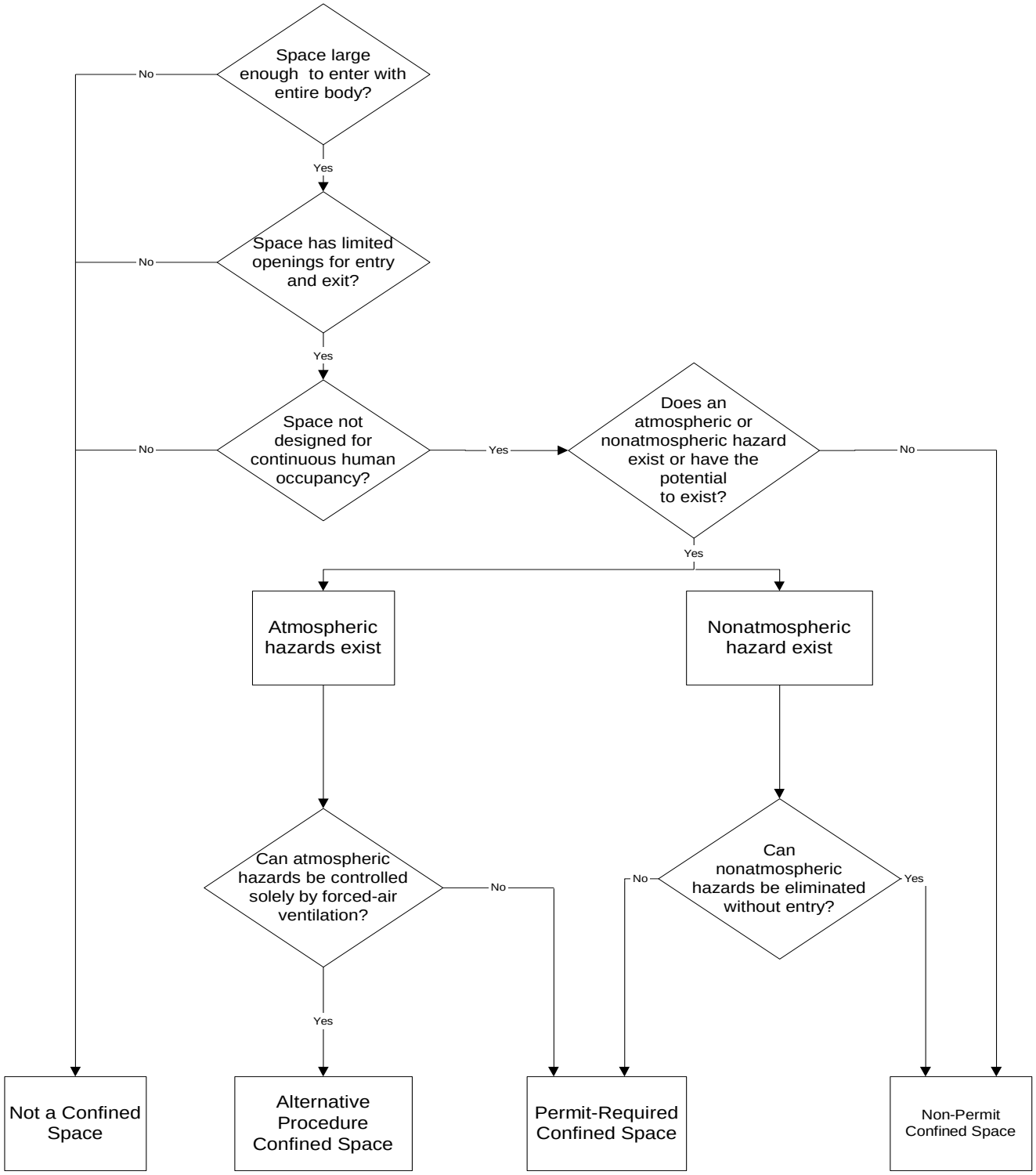
Attachment 3: **HS&E Self Assessment Checklist- Permit-required Confined Space Entry**

Attachment 4: **CH2M HILL Confined Space Entry Permit**

Attachment 5: **CH2M HILL Confined Space Alternate Procedure Certificate**

Attachment 6: **CH2M HILL Confined Space Non-permit Certificate**

Attachment 1: Confined Space Classification Flowchart



Alternate Procedure Confines Space Entry for U.S. use only. All other countries use Permit-required Confined Space Entry procedures.

Attachment 2: Subcontractor Safety Procedure Criteria—Permit-Required Confined Space Entry

The following criteria are not intended to be all-inclusive, but are provided as a tool to facilitate development and review of subcontractor safety procedures. Subcontractors are expected to address the following items in their safety procedures.

Minimum Acceptable Criteria for Subcontractor Permit-required Confined Space Entry Procedures:

1. Provide the name and qualifications of the Confined Space Entry Supervisor responsible for overseeing all confined space entry operations (years and type of experience, training background, etc.).
2. Describe the training requirements for confined space entrants and Attendants.
3. Describe the responsibilities of the Entry Supervisor, Attendants, and Entrants.
4. Describe the methods used to classify confined spaces as permit-required, alternative-procedure, or nonpermit confined spaces.
5. Describe the methods used to isolate confined spaces from the release of energy and material.
6. Describe the methods and equipment used to ventilate confined spaces to provide acceptable safe entry conditions.
7. Describe the communication methods used between entrants and the Attendant.
8. Describe the atmospheric monitoring instrumentation and procedure requirements (qualifications of tester, frequency of tests, instrumentation used, hazards monitored, and documentation of results).
9. Describe the methods used to perform confined-space rescue (non-entry retrieval equipment, internal rescue team qualifications, external rescue team assessment, communication and rescue procedures)
10. Describe the protective equipment used for confined-space entry.
11. Describe the pre-entry briefing requirements (frequency, items covered, attendance required).
12. Describe the methods used for Alternate Procedure Confined Space Entry.
13. Provide the CSEP and certificates to be used.

Attachment 3: HS&E Self-Assessment Checklist—Permit-Required Confined Space Entry

CH2MHILL

HS&E Self-Assessment Checklist – PERMIT-REQUIRED CONFINED SPACE ENTRY

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's Health and Safety Plan/Field Safety Instruction (HSP/FSI).

This checklist is to be used at locations where: 1) CH2M HILL employees will enter confined spaces, and/or 2) CH2M HILL provides oversight of a subcontractor performing confined space entry.

Safety Coordinator (SC) may consult with subcontractors performing confined space entry when completing this checklist, but shall not direct the means and methods of forklift operations nor direct the details of corrective actions. Subcontractors performing confined space entry shall determine how to correct deficiencies, and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____
Location: _____ PM: _____
Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to (check only one of the boxes below):

☐ Evaluate CH2M HILL performance of confined space entries
☐ Evaluate a CH2M HILL subcontractor's compliance with its confined space entry program
Subcontractor's Name: _____

- Check "Yes" if an assessment item is complete or correct.
- Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-203.

SECTION 1	Yes	No	N/A	N/O
CONFINED SPACE EVALUATION (5.2.3)				
1. Personnel informed of location and hazards of existing confined spaces (danger signs, verbal)	☐	☐	☐	☐
2. Determination made that work cannot be completed without entering the confined space	☐	☐	☐	☐
3. Information obtained regarding the space (blueprints, potential hazards, energy sources)	☐	☐	☐	☐
4. Spaces classified as permit-required, alternative-procedure, or nonpermit confined spaces	☐	☐	☐	☐
TRAINING (6.0)				
5. Entrants, Attendants, and Entry Supervisor have completed confined space entry training	☐	☐	☐	☐
6. Employees performing lockout/tagout (LOTO) procedures have completed LOTO training	☐	☐	☐	☐
7. Employees required to wear respirators have completed respiratory-protection training	☐	☐	☐	☐
CONFINED SPACE ENTRY (5.4)				
8. Completed permit or certificate posted at space entrance	☐	☐	☐	☐
9. Pre-entry briefing conducted	☐	☐	☐	☐
10. Entrants/Attendants verify that Entry Supervisor has authorized entry	☐	☐	☐	☐
11. Entrants/Attendants verify that all requirements of the permit or certificate have been satisfied	☐	☐	☐	☐
12. Atmospheric monitoring is conducted at frequency provided on the permit or certificate	☐	☐	☐	☐
13. Entry not permitted if an atmospheric hazard is detected above acceptable safe levels	☐	☐	☐	☐
14. Entrants evacuate space upon orders of the Attendant or Entry Supervisor, when an alarm is sounded, or when a prohibited condition or dangerous situation is recognized	☐	☐	☐	☐
15. Entrants/Attendant informs Entry Supervisor of hazards confronted or created in the space, or any problems encountered during entry.	☐	☐	☐	☐
16. Entry Supervisor informs the owner of such issues in item 15 above	☐	☐	☐	☐

SECTION 1 (continued)	Yes	No	N/A	N/O
ENTRY UNDER A CONFINED SPACE ENTRY PERMIT (CSEP) (5.4.1)				
17. CSEP completed by Entry Supervisor	☐	☐	☐	☐
18. All expected hazards listed	☐	☐	☐	☐
19. Entry Supervisor and Attendant assigned	☐	☐	☐	☐
20. Communication methods established between entrants and the Attendant (5.5.1)	☐	☐	☐	☐
21. Cleaning requirements identified (5.5.2)	☐	☐	☐	☐
22. Isolation requirements identified (5.5.3)	☐	☐	☐	☐
23. Ventilation requirements identified (5.5.4)	☐	☐	☐	☐
24. Protective equipment requirements identified (5.5.5)	☐	☐	☐	☐
25. Rescue equipment requirements identified (5.5.6)	☐	☐	☐	☐
26. Other requirements identified (5.5.7)	☐	☐	☐	☐
27. Rescue and emergency procedures identified (5.5)	☐	☐	☐	☐
28. Atmospheric monitoring requirements identified	☐	☐	☐	☐
29. HS&E manager approved use by signing (CH2M HILL CSEP only)	☐	☐	☐	☐
30. Entry Supervisor authorized entry by signing	☐	☐	☐	☐
31. Authorized entrants have completed CSE training and attended pre-entry briefing	☐	☐	☐	☐
32. Only Authorized Entrants permitted to enter the space	☐	☐	☐	☐
33. Entry Supervisor signed the CSEP indicating its cancellation	☐	☐	☐	☐
34. Problems encountered during the entry listed	☐	☐	☐	☐
ENTRY UNDER AN ALTERNATE PROCEDURE CERTIFICATE (APC) (5.4.2)				
35. APC completed by Entry Supervisor	☐	☐	☐	☐
36. All expected atmospheric hazards listed	☐	☐	☐	☐
37. Entry Supervisor and Attendant assigned	☐	☐	☐	☐
38. Entry Supervisor verifies that nonatmospheric hazards do not exist	☐	☐	☐	☐
39. Communication methods established between entrants and the Attendant	☐	☐	☐	☐
40. Covers removed safely	☐	☐	☐	☐
41. Openings guarded from both fall hazards and from objects entering the space	☐	☐	☐	☐
42. Continuous forced-air ventilation positioned to ventilate the immediate areas where employees are working and continue until they have left the space	☐	☐	☐	☐
43. Ventilation from a clean source of air	☐	☐	☐	☐
44. Atmospheric monitoring requirements identified	☐	☐	☐	☐
45. Entry Supervisor authorized entry by signing APC	☐	☐	☐	☐
46. Authorized Entrants have completed CSE training and attended pre-entry briefing	☐	☐	☐	☐
47. Only Authorized Entrants permitted to enter the space	☐	☐	☐	☐
48. Entry Supervisor signed the APC indicating its cancellation	☐	☐	☐	☐
49. Problems encountered during the entry listed	☐	☐	☐	☐
ENTRY UNDER A NONPERMIT CERTIFICATE (NPC) (5.4.3)				
50. NPC completed by Entry Supervisor	☐	☐	☐	☐
51. Entry Supervisor assigned	☐	☐	☐	☐
52. Attendant or buddy assigned	☐	☐	☐	☐
53. Buddy remains in the space with the entrant	☐	☐	☐	☐
54. Entry Supervisor verifies nonatmospheric hazards do not exist	☐	☐	☐	☐
55. Communication methods established between entrants and Attendant or buddy	☐	☐	☐	☐
56. Entrants informed to exit the space immediately if hazards are observed	☐	☐	☐	☐
57. Atmospheric monitoring requirements identified	☐	☐	☐	☐
58. Entry Supervisor authorized entry by signing	☐	☐	☐	☐
59. Authorized Entrants have completed CSE training and attended pre-entry briefing	☐	☐	☐	☐
60. Only Authorized Entrants permitted to enter the space	☐	☐	☐	☐
61. Entry Supervisor signed the NPC indicating its cancellation	☐	☐	☐	☐
62. Problems encountered during the entry listed	☐	☐	☐	☐

SECTION 1 (continued)	Yes	No	N/A	N/O
RESCUE (5.6)				
63. Entrants wearing body harness with attached retrieval line (lifeline)	☐	☐	☐	☐
64. Other end of lifeline attached to retrieval device (when required) or fixed point outside space	☐	☐	☐	☐
65. Mechanical retrieval device positioned at access point for vertical-type spaces > 5 feet deep	☐	☐	☐	☐
66. Rescue team established	☐	☐	☐	☐
67. Team members have completed confined space entry training	☐	☐	☐	☐
68. Team members informed of the hazards that they may confront during rescue operations	☐	☐	☐	☐
69. PPE and rescue equipment necessary to conduct safe entry-rescue provided & readily available	☐	☐	☐	☐
70. Team members trained on rescue duties and proper use of PPE and rescue equipment	☐	☐	☐	☐
71. All team members trained in first aid & CPR, at least one member holding a current certification	☐	☐	☐	☐
72. Team has made simulated rescue from a space of similar configuration within last 12 months	☐	☐	☐	☐
73. Communication established & tested between the team & entrants, and emergency provider	☐	☐	☐	☐
74. Local emergency medical provider notified in advance of entries into PRCS	☐	☐	☐	☐
ATMOSPHERIC MONITORING (5.7)				
75. Qualified individual conducts atmospheric monitoring	☐	☐	☐	☐
76. Monitoring results documented on permit or certificate	☐	☐	☐	☐
77. Entrants do not enter until all monitoring requirements are completed	☐	☐	☐	☐
78. Monitoring equipment calibrated prior to use	☐	☐	☐	☐
79. Monitoring conducted for oxygen, flammability, and toxic air contaminants	☐	☐	☐	☐
80. Monitoring conducted bottom to top at 5-foot intervals	☐	☐	☐	☐
PRE-ENTRY BRIEFING (5.8)				
81. Entry Supervisor conducts the briefing and discusses the following items:	☐	☐	☐	☐
82. Explanation of the work to be performed and limitations	☐	☐	☐	☐
83. Explanation of actual and potential hazards, including the possible behavioral effects and signs, symptoms, and consequences of exposure	☐	☐	☐	☐
84. Review of the control measure and atmospheric monitoring requirements, as specified on permit or certificate	☐	☐	☐	☐
85. Review of entrant and attendant responsibilities				
86. Hands-on training provided on unfamiliar equipment.	☐	☐	☐	☐

<u>SECTION 2</u>

Complete this section for all items checked “No” in Section 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned or Taken	Date Corrected

Auditor: ________________________________ Project Manager: _____________________________

Attachment 4: CH2M HILL Confined Space Entry Permit

CH2MHILL **CH2M HILL Confined Space Entry Permit**

1.0 GENERAL INFORMATION		
Project:	Project #:	PM:
Date of Entry:	Duration of Entry:	Permit Expiration Date and Time:
Space Location:		
Description of Space:		
Purpose of Entry:		
Hazards Expected: ☐ Oxygen Deficiency ☐ Oxygen Enrichment ☐ Flammable Vapors ☐ Temperature Extremes ☐ Entrapment ☐ Engulfment ☐ Fall ☐ Electrical ☐ Mechanical ☐ Chemical ☐ Pressure ☐ Combustible Dust ☐ Toxics (specify): ☐ Other (specify):		
Entry Supervisor (ES):	Attendant(s):	

2.0 CONTROL MEASURE REQUIREMENTS
Communication: ☐ Visual ☐ Voice ☐ Radio ☐ Cell Phone ☐ Other (specify):
Cleaning: ☐ None ☐ Purging ☐ Inerting ☐ Flushing Date/Time Completed:
Isolation: ☐ None ☐ Lockout/Tagout ☐ Line Breaking ☐ Blinding/Blanking ☐ Double Block & Bleed ☐ Other (specify): Date/Time Completed:
Ventilation: ☐ None ☐ Prior to Entry ☐ Continuous ☐ Periodic (specify frequency): ☐ Type (specify): Date/Time Completed:
Protective Equipment: ☐ GFCI ☐ Low-voltage Lighting: ☐ Fire Extinguisher ☐ Fall Protection ☐ First Aid Kit ☐ Respirators (specify): Other (specify):
Rescue Equipment: ☐ Harness ☐ Lifeline ☐ Tripod ☐ Retrieval Device ☐ Other (specify):
Other Requirements: ☐ Hot Work Permit ☐ Other (specify):

3.0 RESCUE AND EMERGENCY PROCEDURES
(Write in rescue/ emergency procedures specific for this confined space entry, consistent with project emergency contingency plan)

4.0 ATMOSPHERIC MONITORING
Frequency: ☐ Prior to Each Entry ☐ Prior to Shift ☐ Continuous ☐ Periodic (specify):
Instruments: ☐ Combustible Gas Indicator ☐ FID ☐ PID ☐ Colorimetric Tubes ☐ CO Monitor ☐ H_2S Monitor ☐ Other(specify):
Substances Monitored: ☒ Oxygen ☒ Flammables ☐ CO ☐ H2S ☐ Other (specify):

Monitoring Results			**Oxygen**	**Flammability**	**Toxicity**		
Monitors	Limits		19.5 – 23.5 %	< 10 % of LEL	< PEL/TLV		
Initials	Date	Time	%	% of LEL	Substance	Level	Limit

5.0 PERMIT APPROVAL, AUTHORIZATION, AND CANCELLATION				
	Signature	Employee Number	Date	Time
HS&E Approval				
ES Permit Authorized				
ES Permit Canceled				
Problems Encountered During Entry				

CH2M HILL Confined-Space-Entry Permit

6.0 AUTHORIZATION/ACCOUNTABILITY LOG

The following individuals have successfully completed confined space training, have attended a pre-entry briefing, and are authorized to enter the space.

	ES Initials		Attendant - check each time an individual enters or exits the space.											
Name of Entrant	Trained	Briefed	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out

Attachment 5: CH2M HILL Confined Space Alternate Procedure Certificate

CH2MHILL

CH2M HILL Confined Space Alternate Procedure Certificate

Alternate procedures may be used for permit-required confined space entry if the only hazard within the space is an atmospheric hazard and the hazard can be controlled to acceptable safe levels solely by forced-air ventilation. If the space must be entered to determine hazards, the initial entry must be done in full compliance with the requirements of a confined space entry permit.

These alternate procedures are valid as long as the atmospheric hazards are controlled by forced-air ventilation. If additional hazards arise within the space, or the forced-air ventilation is inadequate in controlling the atmospheric hazard, personnel must exit the space immediately and the space must be reevaluated.

1.0 GENERAL INFORMATION		
Project:	Project #:	PM:
Date of Entry:	Duration of Entry:	Certification Expiration Date:
Space Location:		
Description of Space:		
Purpose of Entry:		
Atmospheric Hazards Expected: ☐ Oxygen Deficiency ☐ Oxygen Enrichment ☐ Flammable Vapors ☐ Toxics (specify):		
Entry Supervisor (ES):	Attendant(s):	

2.0 CERTIFICATE REQUIREMENTS

☐ Nonatmospheric hazards do not exist in this space

☐ Communication methods established between entrants and the Attendant

☐ Covers can be removed safely

☐ Space openings guarded from fall hazards and falling objects

☐ Continuous forced-air ventilation from a clean air source is positioned in the immediate area where entrants are working and continue until they have left the space

3.0 ATMOSPHERIC MONITORING

Frequency: ☐ Prior to Entry ☐ Continuous ☐ Periodic (specify):

Instruments: ☐ Combustible Gas Indicator ☐ FID ☐ PID ☐ Colorimetric Tubes ☐ CO Monitor ☐ H_2S Monitor ☐ Other(specify):

Substances Monitored: ☐ Oxygen ☐ Flammables ☐ CO ☐ H2S ☐ Other (specify):

Monitoring Results			**Oxygen**	**Flammability**	**Toxicity**		
Monitors	Limits		19.5 – 23.5 %	< 10 % of LEL	< PEL/TLV		
Initials	Date	Time	%	% of LEL	Substance	Level	Limit

4.0 CERTIFICATE AUTHORIZATION AND CANCELLATION

	Entry Supervisor Signature	Employee Number	Date	Time
Entry Authorized				
Entry Canceled				
Problems Encountered During Entry:				

5.0 AUTHORIZATION/ACCOUNTABILITY LOG

The following individuals have successfully completed confined space training, have attended a pre-entry briefing, and are authorized to enter the space.

	ES Initials		Attendant - check each time an individual enters or exits the space.											
Name of Entrant	Trained	Briefed	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out

Attachment 6: CH2M HILL Confined Space Non-permit Certificate

CH2MHILL

CH2M HILL Confined Space Non-permit Certificate

This non-permit certificate must used when reclassifying a permit required confined space to a non-permit confined space where no actual or potential atmospheric hazard above acceptable safe levels and if all non-atmospheric hazards can be eliminated without entry into the space. If the space must be entered to eliminate non-atmospheric hazards, the initial entry must be done in full compliance with the requirements of a confined space entry permit. If an atmospheric or non-atmospheric hazard is observed, personnel must exit the space immediately and the space must be reevaluated.

1.0 GENERAL INFORMATION		
Project:	Project #:	PM:
Date of Entry:	Duration of Entry:	
Space Location:		
Description of Space:		
Purpose of Entry:		
Entry Supervisor (ES):	Attendant(s):	

2.0 CERTIFICATE REQUIREMENTS

☐ Actual or potential atmospheric hazard above acceptable safe levels do not exist in this space
☐ Non-atmospheric hazards do not exist in this space or have been eliminated without entry
☐ Communication methods established between entrants and the buddy or Attendant
☐ Entrants are informed to exit the space if any hazard is observed

3.0 ATMOSPHERIC MONITORING

Frequency: ☐ Prior to Entry ☐ Continuous ☐ Periodic (specify):

Instruments: ☐ Combustible Gas Indicator ☐ FID ☐ PID ☐ Colorimetric Tubes ☐ CO Monitor ☐ H_2S Monitor ☐ Other(specify):

Substances Monitored: ☐ Oxygen ☐ Flammables ☐ CO ☐ H2S ☐ Other (specify):

Monitoring Results			**Oxygen**	**Flammability**	**Toxicity**		
Monitors	Limits		19.5 – 23.5 %	< 10 % of LEL	< PEL/TLV		
Initials	Date	Time	%	% of LEL	Substance	Level	Limit

4.0 CERTIFICATE AUTHORIZATION AND CANCELLATION

	Entry Supervisor Signature	Employee Number	Date	Time
Entry Authorized				
Entry Canceled				

5.0 AUTHORIZATION/ACCOUNTABILITY LOG

The following individuals have successfully completed confined space training, have attended a pre-entry briefing, and are authorized to enter the space.

	ES Initials		Attendant - check each time an individual enters or exits the space.											
Name of Entrant	Trained	Briefed	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out

Problems Encountered During Entry